Using Data Visualization to Design FCS Task-Based Training

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ABSTRACT

The Army's approach to task-based training includes the key instructional design activity of "packaging" collective tasks into logical groupings. These groupings of tasks form the basis for the design of instructional events that will be conducted using live, virtual and constructive training approaches. For the Future Combat Systems (FCS) equipped Brigade Combat Team (BCT), nearly 1000 collective and leader and battle staff tasks have been identified. Grouping a large number of tasks into training activities such that all critical tasks and skills are practiced with appropriate sequencing and repetition is an instructional design problem encountered in many training programs, but particularly critical for the FCS program as it prepares to train Soldiers to implement a new family of weapon systems.

This paper presents a new approach to this traditional instructional design challenge. The approach involves the use of a data visualization tool being used on the FCS program that allows a number of specific relationships between and among collective and individual tasks to be displayed graphically. The graphical display of task data permits rapid examination of task dependencies, hierarchical relationships, skill and knowledge commonality, and other linkages critical to support training design decisions. A small group tryout was conducted to evaluate the effectiveness of the tool for designing task-based training. The results were positive, yet less than desired. The shortcomings identified were primarily the result of incomplete functionality needed to fully implement the task-based training design approach that was targeted. However, glimpses of the tool's exceedingly rich potential for training design were evident in the tryout. The development of new functionality to meet the identified gaps is ongoing.

ABOUT THE AUTHORS

David Olsen is a Senior Systems Analyst for Dynamics Research Corporation. He has 23 years experience designing and developing military training systems. His work has included examination of training, human factors, manpower, and cost issues impacting training system design and implementation. He has been involved in the design of numerous training systems encompassing various configurations of embedded training, multimedia, and virtual and constructive simulation. Recent work has focused on user interface design and usability assessment for WARSIM, JSIMS, and CCTT. His current assignment as Deputy Program Manager for DRC's effort is to guide process issues for the development of Training Support Packages (TSPs) for the Future Combat Systems (FCS).

Gabriel Aviles is a Semantic Systems Architect for Orbis Technologies, Inc. He is an early adopter of semantic web technology (Web 3.0); researching and developing solutions that leverage this technology for that last 7 years. He participated in the DARPA/DAML Computer Aided Knowledge Engineering research and development effort to define a Semantic Web language, DAML+OIL which evolved to OWL (Web Ontology Language); a W3C Recommendation. For the last 10+ years he has designed and developed solutions for DoD related government contracts, from the front-end to back-end and the business logic and services in between. He has a B.S. in Electrical Engineering from Boston University, with a concentration in software, digital signal processing, and music theory and composition.

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The Instructional Design Challenge

The U.S. Army is a strong proponent of task-based training. Task-based training is performance oriented and involves the selection and practice of collective (unit) tasks and supporting skills and knowledge to ensure units and soldiers can perform to a specified standard. (TRADOC Regulation 350-70). For the emerging FCS equipped Brigade Combat Teams (BCT), 462 collective tasks have been identified for the 81 elements (units) of the FCS (BCT). In addition, 430 leader and battle staff (LBS) tasks have also been identified for the approximately 700 positions making up the elements of the FCS (BCT). The instructional design challenge that underlies task-based training is how to group and sequence the multitude of collective and LBS tasks such that sufficient training opportunities will exist to fully prepare units and soldiers for their assigned missions. Each of these task-based training opportunities will be specified in the form of a Training Support Package (TSP). The TSP will be a self contained training package containing all the information and materials to train one or more collective and LBS tasks. TSPs for the FCS (BCT) will be designed to be implemented using simulation training approaches, either virtual or constructive. How many TSPs are needed and what tasks (collective and LBS) should be addressed in each? This design challenge would make the most competent instructional designer wake up in a cold sweat with night mares of spreadsheets covering entire walls. Presenting task data and relationships among the task data elements in a visual manner offers a potentially valuable approach to designing task-based training. This paper presents the interim results of a project that is using data visualization to address this frequent instructional design challenge within Army training.

Data Visualization

Data visualization is a rapidly advancing field of study both in terms of academic research and practical applications. Specialization is occurring as part of this evolution resulting in multiple terms to describe different types of visualization activities. For example, *data* visualization refers to the creation of visualizations to understand complex data. The term *knowledge* visualization has emerged and refers to the use of visual representations to improve the creation and transfer of knowledge between at least two people. *Information* visualization, yet another form of visualization, involves the use of interactive visual representations of data to amplify cognition. Throughout this paper, the term ***data visualization*** is used to collectively represent the various forms of visualization. While the terms may vary, there is a great deal of agreement with respect to the potential benefit of representing data, knowledge or information visually. Burkhard (2005) summarizes these benefits as the following:

Attention: The ability of a visualization to attract, direct, and keep the attention of the participants.

Recall: The ability of a visualization to convey content in a memorable way.

Overview: The ability of a visualization to synthesize detail and provide a macro structure that organizes many elements into a coherent whole.

Comprehension: The ability of visualization to foster understanding, learning, and sense making activities by showing relationships.

Discovery: The potential of a visualization to trigger new insights for its users/participants by highlighting meaningful, interesting patterns.

Emotion: The ability of a visualization to trigger functional emotional responses to it.

Coordination: The ability of a visualization to guide a group of people and provide common points of reference.

An exceptionally useful web site that provides a summary of various types of visualization methods can be found at http://www.visual-literacy.org/periodic_table/periodic_table.html.

Approach

Defining the Questions for the Data Visualization

The design of an effective data visualization begins with the creation of a question or series of questions to which answers are needed. Without a question to be answered the data/information displayed in the visualization will be useless, regardless of how cleverly or eloquently it is displayed. For this project, this conclusion was arrived at not by design but by experience. The initial approach was to build a data visualization that would display any task related data items that might be valuable in meeting the training design objective, i.e., grouping tasks into TSPs. Within the visualization tool, a capability was developed to allow the user to turn on or turn off data/information and relationships that were not helpful. Essentially, the approach was to build a generic data visualization of task data/information and relationships, and let the user figure out what was valuable. From this misguided approach the phrase *"Data in search of a question"* was coined. There are times when it may be necessary to explore data/information and relationships initially before a succinct question emerges to be answered. In these cases, displaying a buffet of data/information and relationships might be necessary. However, this approach can easily lead to a case of "TMI" (Too Much Information) being displayed at any given time. TMI can wipe out the benefits that are gained by using data visualization to foster the understanding of large amounts of information.

For our project, the capstone question related to how to group tasks into TSPs.

"What are the optimal groupings of collective and LBS tasks such that the underlying skills and knowledge have sufficient opportunities to be acquired?"

This question formed the basis for nearly all subsequent project activities including designing and developing the visualization capabilities. Inherent in the capstone question are a number of fundamental concepts of sound instructional design as reflected in the Instructional Systems Development (ISD) process. These concepts include the premise that in order for a unit to perform a collective task to standard, the individual members of the unit must have sufficient practice opportunities to acquire the underlying individual tasks, skills and knowledge that are pertinent to each member.

From our capstone question, a series of supporting questions emerged. The answer to each of these questions would provide additional information to help answer the capstone question. For each supporting question, the data/information that was required was identified along with a way to display the data relationships or what were referred to as "views" within the visualization tool. For example, one supporting question that needed to be answered was *"what are the LBS tasks that support the performance of a collective task"?* This information was essential to understand the hierarchical relationships between collective and LBS tasks. Dynamically displaying these relationships in a view would enable the TSP designer to quickly see that by selecting a particular collective task for incorporation into a TSP, a number of LBS tasks would also be candidates for incorporation into the same TSP. Figure 1 depicts the approach of defining a capstone question, supporting questions and the data needed to answer the questions.

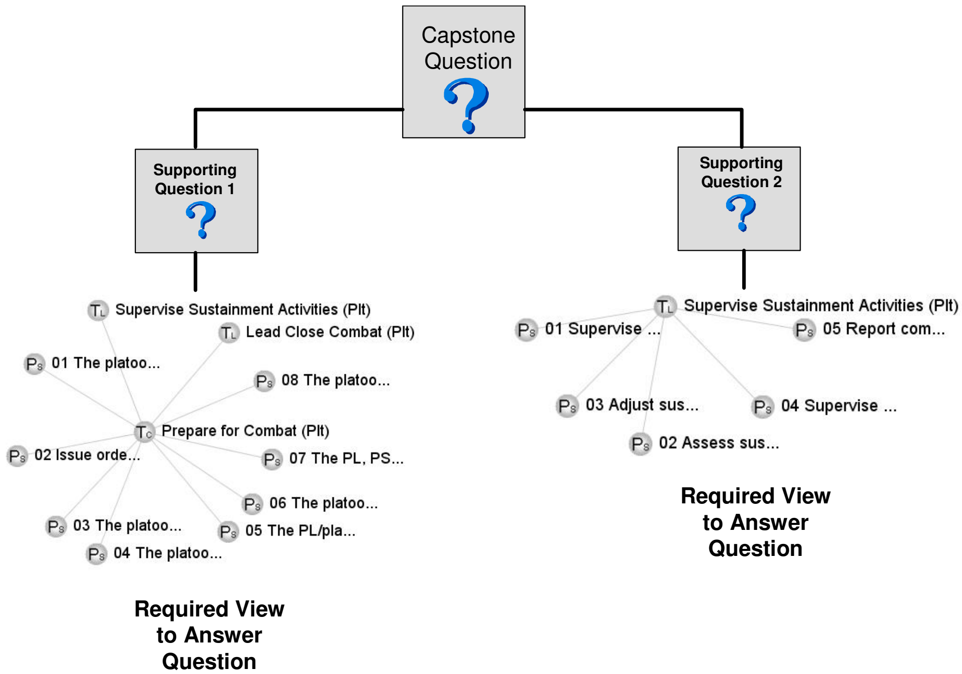

Figure 1. Designing the Data Visualization

Selecting the Data Visualization Tool

Project team members had previously worked with several data visualization tools and were aware of their potential to help manage and analyze large amounts of information. For this project, the ThinkMap™ Software Development Kit (SDK), www.thinkmap.com, was selected. Key selection criteria included licensing costs, potential to implement data visualization through the web, responsiveness of technical support, and capabilities related to the project's particular data visualization needs.

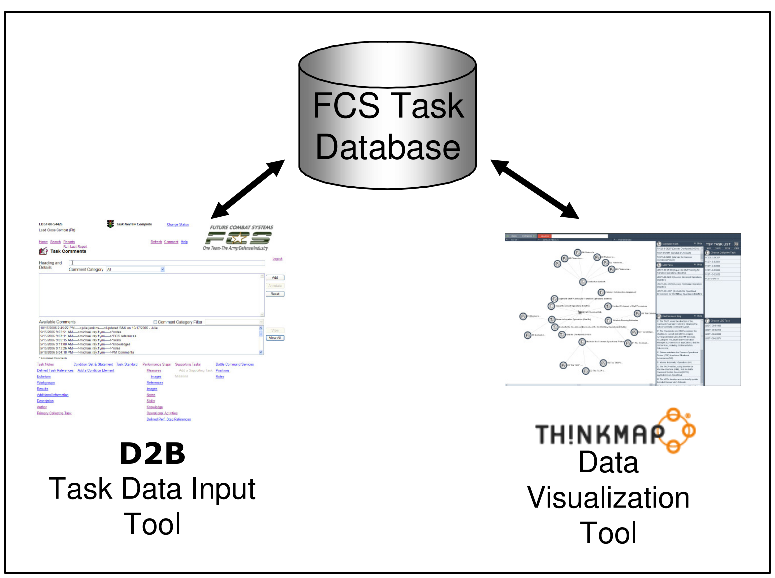

Figure 2. Task Data and Visualization Tool

The ThinkMap tool was layered on top of the task relational database being used for FCS (Figure 2). Any task data and relationships existing in the database were available for display in the data visualization tool via ThinkMap's native query capability. By connecting to the data via a Java Database Connectivity (JDBC), ThinkMap enabled the application to deploy as a Java 2 Platform Enterprise Edition (J2EE) web application.

Evolving the Data Visualization Tool Capabilities

A rapid prototyping approach was adopted for evolving the tool's visualization capabilities. While the ThinkMap™ SDK has many robust capabilities and available plug-ins, the SDK allowed for new functions to be designed and developed using JAVA. ThinkMap™ technical support personnel were exceptionally responsive in providing a roadmap for developing new functions. The design and development approach for the needed visualization capabilities was to incrementally design and build with frequent usability testing to determine if the approach being taken and the functionality would enable answers to the capstone and supporting questions.

Designing a task-based TSP and determining how to group tasks for training is a highly cognitive activity. To a great extent the process is subjective, despite adherence to strict ISD protocol for training design. The process that is used to identify what tasks to group together as part of a task-based training activity will vary greatly depending upon experience and background of the training designer. From interviews with various groups who are designing task-based training, two approaches predominated. One approach was top down. This approach starts with either a mission or a unit/element to be trained. Collective tasks associated with the mission or unit are evaluated to determine how to best group and sequence them to bring about desired training outcomes. The other approach was bottom-up. In this approach, the training designer is concerned with the underlying skills and knowledge that have been identified as deficient or need practice as part of an overall training regimen. The target skills and knowledge are mapped to individual tasks that are in turn mapped to collective tasks that provide the necessary context/setting for training.

The design and development approach for the tool's capability was to enable either a top-down or bottom-up approach. A series of user feedback sessions resulted in building the data visualization selections (referred to as "views") to display the task data elements and relationships identified in Figure 3.

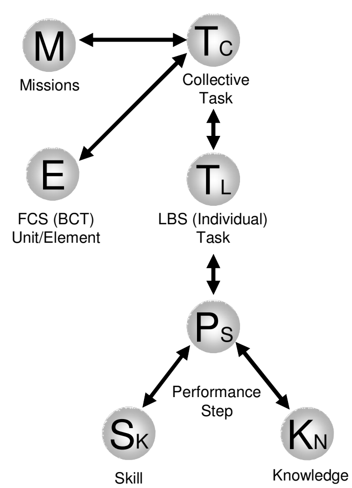

Figure 3. Task Data Elements for Visualization

Within the tool, the user is free to visually explore various task data and relationships to help determine the best way to group tasks for training. For example, the user can display all the collective tasks for a specific unit/element (Figure 4. Unit/element at the center of the view).

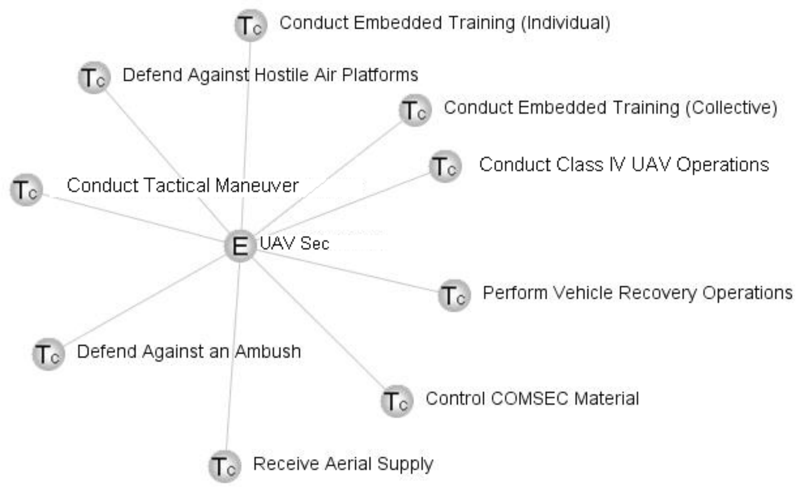

Figure 4. Task to Element/Unit View

The user can center on a single collective task to identify the potential supporting LBS tasks that would be appropriate to train (Figure 5. Collective task at the center of the view). The user can also select to display the high level performance steps for the collective task.

Progressively, the user can explore the relationships among task data elements. Often, this requires examining the underlying skills for an LBS task and determining whether these skills should be trained as part of the particular TSP being designed. Perhaps, the skills overlap from one task to another. Displaying this information visually helps the training designer determine optimal ways to group tasks into TSPs.

Figure 5. Collective Task to LBS Task View

Designing the TSP

The Shopping Cart

In order to assist with the design of task-based training, the visualization tool needed to do more than just display data and information. As shown in Figure 6, a shopping cart model was identified via user feedback as the most effective approach to select the tasks that would be incorporated into the TSP. This paradigm, which is familiar to internet shoppers, enables the task-based training designer to fill a shopping cart that represents the tasks to be trained for a specified TSP. To add to the shopping cart on the far upper right, the user right clicks the selection from the view on the left. Users were allowed to select collective tasks, LBS tasks and performance steps associated with each of the tasks.

Figure 6. TSP Shopping Cart

Use Case Description

In the example shown in Figure 6, a TSP called "MCG2 (Mobile Command Group 2) Planning (Walk)" has been designed at the "Walk" level of difficulty. The designers were a group of subject matter experts who accessed the visualization tool simultaneously via the web from various geographic locations. Once the purpose of the TSP was agreed upon, a unique identifying number and title were assigned. Candidate tasks, their contents, and relationships to other tasks were examined and discussed among the online participants for potential inclusion in the TSP. Various views were displayed to better understand the task data. One view that was displayed contained categories of task conditions (e.g., enemy threats, obstacle types) that had been identified in the original task analysis data as greatly impacting the difficulty of the task. These conditions were examined to help the designers better determine the optimal training context for the task, which supported a discussion on other potential collective tasks to be added to the shopping cart.

A first cut of collective tasks was completed by one of the TSP designers such that the tasks represented a continuum of events that addressed the desired training outcome. A second designer at another location added several additional tasks to the shopping cart. The other designers refreshed their screen and viewed the updated contents. Through this form of collaboration and manipulation of the view to display various task relationships, consensus was reached on the collective tasks for the TSP. The view was modified to show the LBS tasks supporting the collective tasks. Each LBS task was evaluated for applicability to the desired outcome of the TSP. Examination of the LBS tasks included an evaluation of the associated skills that would be trained by incorporating specific LBS task into the TSP.

With the collective and LBS tasks identified, the task performance steps for each of the selected task were examined for inclusion in the TSP shopping cart. Selection of specific performance steps, rather than all performance steps would enable training to focus on specific performance activities deemed more critical. At the conclusion of the session a TSP report was generated showing the various collective and LBS tasks, along with specific task performance steps that would be evaluated during training.

A task to TSP matrix was also auto-generated (Figure 7) showing which tasks had been incorporated into the various TSPs and the frequency that a task is incorporated into TSPs. This matrix was used to determine if every task would have at least one TSP. The matrix also assisted in determining if certain tasks, considered more critical or difficult to perform, and should appear in multiple TSPs.

Task Number	Task Title	CAB Staff Planning – Attack of Fortified Area (TSP07-01-0001)	MCG2 Planning (Walk) (TSP71-06-0002)		Total TSPs for Task
FCS71-1-S2055	Conduct Battalion Course of Action Analysis	X			1
FCS71-1-S2151	Conduct Battalion Intelligence, Surveillance, and Reconnaissance Operations	X			1
FCS71-1-S2152	Plan Battalion Intelligence, Surveillance, and Reconnaissance Operations	X			1
FCS71-1-S2154	Perform Localized Intelligence Preparation of the Battlefield	X			1
FCS71-1-S2552	Conduct Localized Logistics Preparation of the Battlespace (LPB)	X			1
FCS71-6-S2002	Maintain Running Estimates	X	X		2
FCS71-6-S2053	Conduct Collaborative Assessment	X	X		2
FCS71-6-S2055	Conduct Collaborative COA Analysis	X			1
LBS17-00-U1011	Supervise Staff Evaluation of the Operational Environment (Bde/Bn)	X			1
LBS71-00-S2410	Evaluate Maneuver Sustainment Plans (Bde/Bn)	X			1

Figure 7. Task to TSP Matrix

Results

A small group tryout was conducted to evaluate data visualization to support the design of task-based training. Seven areas of focus were included in the evaluation and are discussed briefly.

Display of mission to task relationships. This view was essential to understand relationships between tasks and missions. The view designed was satisfactory, although for some missions the large number of mission to task relationships resulted in a view that was not usable without a lot of manipulation. The recommendation that resulted was to build additional categorization filters to limit problems with displaying information.

Display of task to unit and echelon relationships. This view provided essential information to understand the relationship between tasks, FCS elements/units and echelons. The view that resulted was assessed as satisfactory.

Display of task hierarchies (e.g., supported and supporting tasks). This view was critical to quickly see how tasks are related (supported and supporting relationships). The view created met the needs of all evaluators.

Task sequencing (temporal relationships). This view was identified as a potential valuable mechanism to visually display how tasks could be sequenced as part of the TSP design. This view was still under construction at the time of the small group tryout and could not be evaluated.

Skill and knowledge commonality. This view provided information on the commonality of skills and knowledge across tasks. While the view provided skill and knowledge information for task performance steps, determining commonality was not easily discerned from the view. The resulting recommendation was to better standardize terminology for skills and knowledge, and assign the skills and knowledge to categories that could be displayed in a manner that would more readily support evaluation of commonality.

Task to Training Support Package (TSP) Allocation View This view was intended to provide a summary of each task and the TSPs to which the task was assigned. With this view, the user would be able to quickly identify potential gaps between FCS tasks and TSPs; that is tasks that have not yet been incorporated into a TSP. This view was simulated for the purpose of the tryout but was not formally evaluated. Favorable comments were received on the simulated view.

TSP task Selection. This view was critical to building a mechanism to identify and flag the collective and LBS tasks, along with selective performance steps that would constitute a TSP. The view and shopping cart methodology created met this goal.

Conclusions and the Road Ahead

Work is continuing to evolve additional capabilities for the data visualization tool, as well as to refine the process for effective task-based training design in a collaborative environment. New strategies are needed to deal with TMI, specifically when the user desires to see multiple relationships within one display, but these relationships cannot be presented within the available screen real estate without creating an "eye chart". Also, a flexible report mechanism is needed to capture and display summary data.

Overall, the results were positive, yet less than desired. The shortcomings identified were primarily the result of incomplete functionality needed to fully implement the task-based training design approach that was targeted. However, glimpses of the tool's exceedingly rich potential for training design were evident in the tryout. The development of new functionality to meet the identified gaps is ongoing.

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