PREPARING FOR THE INSTRUCTIONAL TECHNOLOGY GAP – A CONSTRUCTIVIST APPROACH

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Abstract

Advances in technology have led the U. S. Army to design the Classroom XXI Master Plan (U. S. Army Training and Doctrine Command, 1996). This plan includes the introduction of an in-class simulation, and student and instructor integrated computer workstations to support student-centered, experiential learning at higher levels such as officer advanced training. The plan also encourages the U.S. Army schools to experiment with the use of technology. We proposed that full exploitation of the advantages of new instructional technology could only be achieved through a review of the training requirements, the learning process, and their relationships to instructional media. To address this issue, a Concept Experimentation Program (CEP) effort was conducted by the U. S. Army Research Laboratory to support the U.S. Army Field Artillery School's (USAFAS) Classroom XXI development. Phase I of the CEP included 1) an analysis of the training tasks in the Field Artillery Officer Advanced Course (FAOAC), 2) a review of instructional literature, and 3) a review of current and potential instructional media. Based on our reviews, we concluded that a shift in the Army's current training paradigm to a process that is less linear is desired at the advanced level. Specifically, a constructivist approach informed by Cognitive Flexibility Theory would best support the Army's plan. The theoretical basis of the approach, our refinement of the student-centered learning process, the role of constructivist instruction as a precursor to simulation-based training, and resulting design principles are described. In Phase II of the CEP, we designed and developed proof-of-principle courseware to illustrate the concepts developed in Phase I. User input during Phase II is described regarding desired design features and factors of user acceptance. Requirements for more complete development include research to design instructional facilitation procedures, the need for cognitive authenticity in constructivist instruction, and integration of learner motivation factors in design and development.

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Advances in technology have led the U. S. Army to design the Classroom XXI Master Plan (U. S. Army Training and Doctrine Command, 1996). This plan includes the introduction of an in-class simulation, and student and instructor integrated computer workstations to facilitate student-centered, experiential learning in officer advanced training. The plan also encourages the U.S. Army schools to experiment with the use of technology at the local level. To support the U.S. Army Field Artillery School's (USAFAS) experimentation with technology, the U.S. Army Research Laboratory conducted a Classroom XXI Concept Experimentation Program (CEP) effort to investigate the use of simulation and other automation for the Field Artillery Officer Advanced Course (FAOAC) small group instruction (SGI).

Our focus in examining the FAOAC training was on advanced military training—the "military art"—as opposed to the "science" that is composed of technical and procedural tasks and their training. Literature discussing the future of Field Artillery and the digitized battlefield indicates that the officer's battlefield tasks are likely to become increasingly conceptual.

> Fire execution will be an inherent function of the systems…fire supporters will focus on assisting the commander primarily with the conceptual aspects of fighting with fires, establishing and refining protocols, intuitive analysis and decision-making…Future artillery leaders will require intuitive, tactical judgment to a greater degree than ever before.
> Baxter, 1994, p. 13

Due to the highly conceptual nature of advanced officer performance in Field Artillery, we proposed that full exploitation of new technology would require 1) an analysis of the training requirements; 2) a literature review to determine the learning process most appropriate to the highly conceptual tasks such as those found in the art of Fire Support; and, 3) a review of instructional media to determine the most effective instructional technology to support the identified learning process. Phase I of the CEP accomplished these tasks and resulted in an instructional strategy. The goal of the strategy was to establish a scientific basis for the effective use of technology in relationship to the nature of the tasks to be trained. In Phase II, we designed and developed proof-of-principle courseware to illustrate the strategy. User input was solicited by means of individual interviews and group focus sessions to guide our process in Phase II.

PHASE I: INSTRUCTIONAL STRATEGY DEVELOPMENT

Cognitive Task Analysis

To determine the conceptual nature of the current advanced training tasks, a cognitive task analysis was conducted. The procedure included a content analysis of the terminal learning objectives (TLOs) and the enabling learning objectives (ELOs) in the current program of instruction (POI) and a survey of instructors-subject matter experts (SMEs). The objective was to categorize the tasks by means of Bloom's taxonomy (Bloom, 1956), the cognitive task taxonomy in common use by U.S. Army training developers.

Bloom's taxonomy consists of six cognitive levels for learning objectives ranging from those requiring the most concrete to the most complex cognitive behaviors on the part of the student. The six cognitive levels are:

- Knowledge – Recognition, familiarity, recall.

- Comprehension – Translation, interpretation, extrapolation.
- Application – Use of concepts in new situations. Ability to predict effects based on general principles.
- Analysis – Identification of known general principles within a given setting. Check hypotheses against information and assumptions.
- Synthesis – Development of a plan or communication that conveys experience and ideas to others. Ability to make discoveries and generalizations across settings.
- Evaluation – To make quantitative and qualitative judgments. Compare theories or generalizations.

The instructors were asked to categorize each Field Artillery task as it was stated in the TLO into one of the cognitive levels. Definitions and examples of the cognitive levels were provided. Instructors were asked to think about each task as it would be carried out by a new FAOAC graduate to be successful in his next assignment.

Findings indicated that few tasks in the small group instruction portion of the POI are at the Knowledge or Comprehension levels. An example of a Comprehension Level TLO is: Given a tactical scenario, describe U.S. Army's doctrine concerning military operations other than war.

Generally, the TLOs are at the mid- to high-level of cognitive skills in this taxonomy. More of the 37 TLOs were found to be at the Application Level (46%) than any other level. Examples of TLOs at the Application Level are

- Given a tactical scenario, plan the employment of special munitions.
- Given a tactical scenario, prepare a schedule of fires.
- Given a tactical situation, apply the Top Down Fire Planning process.
- Given a tactical situation, plan the logistics for a field artillery battalion.

Thirty-five percent were placed at the Analysis, Synthesis, and Evaluation levels, although the instructors and the content analysis differed somewhat in the placement of the objectives among the three levels. Examples of the TLOs at these levels are

- Given a Task Force operations order, apply troop leading procedures at Company/Team level.
- Given a tactical scenario, maneuver commander's concept of the operation, fire support assets available, and input from Fire Support Element (FSE) representatives, develop and rehearse a fire support plan.
- Given a scenario involving joint and light forces, employ light/heavy forces in conflict.

Identification of Instructional Technology Gap

A review of the instructional media in use in the FAOAC indicated that despite the presence of new technology, traditional media still dominate instruction. Computer generated slide presentations to support lectures and discussions are the only consistently used new medium.

No specific computer-based courseware for use in residence has been developed for this course at this time. Military advanced instructional technology currently in the classroom is limited to the use of tactical planning equipment emulators (PC-based) and the Janus simulation. These technologies support only 3 of the 37 TLOs in the two experimental classrooms, although a significant portion of time is associated with the three TLOs. The POI prescribes a total of 96 hours for the training of these three TLOs out of the 350 hours allotted to the 37 TLOs examined (or 27% of the total teaching time). Although instructors would like a more dynamic, simulation-based experience for students in small group instruction, time to create and implement additional vignettes in the Janus simulation is a barrier given the instructors' other duties.

Our conclusion was that while the majority of instructional materials available are appropriate for the Knowledge and Comprehension levels. Higher levels of learning and practice are supported by instructor developed practical exercises prior to the use of a simulation for the three targeted TLOs. No technology-based products are available to support higher level cognitive skills acquisition outside of the use of a full-scale, realistic simulation.

Training and multimedia production in the Army are geared to Knowledge and Comprehension learning products, because the majority of Army training is procedural or technical. In addition, training products at the higher cognitive levels are resource intensive to construct. As a result, students and trainees are often put directly into

simulation-driven exercises with only Knowledge and Comprehension level training as a precursor.

Simulation-based training can rapidly take a student into and past the Application cognitive level. Instructors cited the difficulties associated with students playing roles in a realistic simulation of staff members with which they were not familiar. Students often made elementary mistakes in assumptions or biases in applying knowledge in simulation-based training. While this type of behavior is not surprising, it led to the conclusion that some type of preparatory training should be designed for implementation prior to the expensive use of realistic simulation which is fairly resource intensive.

The precursor instruction must provide experience with these higher cognitive behaviors prior to the use of simulations. This strategy will maximize the training effectiveness of simulations in the Army. Simulations will only be used for exploration and practice by the truly advanced student and student group. A review of the literature was conducted to ascertain what methods could best be used to fill this instructional technology gap.

Literature Review

The key elements guiding our literature review were the needs to support

- higher level cognitive learning
- maximum learning transfer
- student-centered learning
- exploitation of advanced technology

Our literature review led us to conclude that a constructivist instructional strategy, informed by Cognitive Flexibility Theory, would best support the cognitive nature of officer advanced training. Constructivism is not new, but the increased volume of information and new opportunities provided through technology have created a renaissance of this educational perspective.

Constructivism. A constructivist renaissance has occurred as the result of

- research into patterns of transfer failure resulting in a search for an approach to overcome transfer failure,
- information overload which makes domain content mastery an unrealistic goal in many arenas of performance,

- and, the increasing ability of new forms of technology to allow interactive forms of random access instruction that supports the creation of more realistic training short of simulations.

Constructivism is based on the assumption that meaning is constructed by the learner, not imparted by the teacher, and that the construction of meaning is forever cognitively associated with the context in which principles and information are initially encountered. The process of constructing meaning is based on the student's perception of problems and the forming of inter-relationships among information into an individualized concept map. The teacher's role is to present authentic problems, coach during problem solving, facilitate linkages among information and concepts, and provide ways for the learner to externalize understanding for evaluation.

This concept of learning effects a very different approach to training development than is found in traditional training efforts. The training designer 's role is not limited to discovery or expression of the principles, processes, and content of a specific domain. The developer must also authentically represent the domain, present challenging problems to the student, and embed problem-solving information within the training context.

The key elements found in a constructivist approach are that

- learning must be situated in authentic experiences that motivate the learner to solve intrinsically interesting problems,
- a student must have an opportunity to view problems from multiple perspectives,
- collaborative learning supports the development of problem solving skills,
- the instructor's role is to provide coaching in the form of scaffolding at crucial times to allow a student to push past present limits,
- learner control is necessary to facilitate the learner's construction of understanding, and
- assessment must be continuous and learner controlled.

Levels of fidelity and authenticity to create intrinsically interesting training challenges must be tailored to the level of expertise. Authenticity

refs to whether the student perceives the training context and challenges as genuine and orderly. Authentic training contexts can be achieved by conforming to the student's general beliefs about how a domain operates. Fidelity—a term often used in relationship to simulations—refers to the degree of exact correspondence a model has with the dynamics, conditions, and facts of the modeled context.

We are aware from other research we have conducted that the level of fidelity of a simulation can affect the participants' satisfaction with and the performance during training depending on the level of expertise of the trainee. In the conduct of training in a full-scale simulation with a Field Artillery Direct Support battalion, we found that there was a difference in perception of the training event based on experience. The most experienced trainers in the group, Non-commissioned Officers (NCOs) had a less positive opinion of training in the synthetic, simulation-driven environment than those participants with less training experience either soldiers or officers (Ross & Pierce, in press).

We also found an interaction between expertise and fidelity in a second experiment recently conducted (Pierce, Hallion, Fowlkes, McCluskey, & Dwyer, 1998). Two units participated in this experiment, and unit two was rated as better prepared and better trained going into the experience. In this case, a more inflexible simulator-stimulator was used to drive the training experiment, rather than a full-scale simulation. For the highly prepared soldiers, the exercise was viewed as repetitive and as a distraction, with performance scores decreasing over the course of training largely due to boredom.

An on-screen, computer-based simulator created through a constructivist approach is not meant to be a full-scale, realistic simulation, and cannot train to the level that a simulation can. Nor is a simulation a desirable a replacement for reality in all training cases (de Keyser & Nyssen, 1998). Decisions about what level of technology to use can be made more easily when there is a good understanding of the training audience's level of expertise.

In addressing this instructional technology gap, we were specifically interested in the role of constructivist instruction as a precursor to simulation-based training. Our audience was not comprised of novices, nor were they experts. In filling the gap between paper-based products aimed at the Knowledge and Comprehension

levels and the use of full-scale simulations, we concluded that an on-screen representation of the task was appropriate. Discerning the nature of authenticity needed for the training audience would depend on the use of feedback gathered from instructor-SMEs during design and development.

Heller (1997) provides a perspective that helps us make design decisions about the level of authenticity. Her study of the interaction of media and levels of abstraction provides guidance as to how we might display information for the student who is just emerging from the novice stage.

Assuming that the learner who is closer to novice than expert is at a more concrete level of learning, Heller's work would suggest that we use full representations of text, sound, graphics and motion to deliver learning. One can infer, perhaps, that more authenticity may be perceived by a student just entering the advanced level of study through the integration of video or realistic graphics or the use of text fully representative of the products one would encounter in a domain, for example.

Cognitive Flexibility Theory. In order to tailor constructivism to advanced military training, we examined Cognitive Flexibility Theory. Spiro, Jacobson and others have developed this theory, as a basis for instruction at the advanced level. (See Jacobson & Spiro, 1994; Jacobson & Spiro, 1995; Spiro, Feltovich, Jacobson, & Coulson, 1992; Spiro et al., 1992).

Cognitive Flexibility Theory was identified as particularly appropriate to high-level cognitive training found in the military. Advanced military officer training differs from other forms of military training in that there is no one right answer. Procedures, principles and information are applied to the best judgment of the problem solver in the given situation. All possible situations cannot be predicted, and the problem solver must be flexible in the application of what has been learned. Changes in operational requirements and technology have made the flexible nature of military decision making even more pronounced.

Spiro, Feltovich, Jacobson, and Coulson (1992) refer to this type of domain as ill-structured. Ill-structured domains are defined as those in which each case of knowledge application involves multiple concept structures, both concepts and cases are complex, and the pattern of concept application can vary substantially across cases that may seem to be similar on the surface.

"Appropriate strategies for advanced learning and instruction in ill-structured domains are in many ways the opposite of what works best for introductory learning and in more well-structured domains," (Spiro, et al., 1992, p. 62). Learning to use knowledge in a variety of ways in diverse circumstances cannot be based on rigidly prepackaged training schema.

The emphasis of Cognitive Flexibility Theory is on advanced learning. The advanced learner is neither a novice nor an expert. The importance of this stage of learning has been largely overlooked in much of training development. The learning process of the advanced student in an ill-structured domain is unique, and a period of sustained exploration is required to move through this stage. Problem solving in this stage is composed of successive iterations of problem definition, sub-problem definition and discovery, and the construction of goals and solutions. Equilibrium points are created by the student and are annihilated in the problem space as new perceptions are gained. Periods of disequilibrium lead to new discoveries and the creation of new equilibrium points in the problem space (Young, 1995). It is only through sustained involvement in this iterative process that a student learns to attune perception in ill-structured domains and to tolerate the ambiguity of disequilibrium at the performance level of the expert.

Student-Centered Learning Process

The student-centered learning process has been advocated for advanced training in Classroom XXI. Only by supporting this process and providing an authentic context can we provide the period of sustained exploration needed for the advanced learner, but the process has not been well defined so as to inform training developers and instructors how to implement the approach.. Figure 1 below offers a refinement of this approach showing specific actions so that training tools and instructional facilitation can be designed to support the process.

The depiction of the student-centered process shows the actions of the student and the corresponding actions of the facilitator during instruction. Facilitation can be provided by a live instructor *or even carefully prepared feedback from automation, peers, and self-reflection*.

Instructional Principles for the Design of Advanced Training

A synthesis of our literature review also resulted in a list of design principles. These principles were used to guide the specification of features in the proof-of-principle product and to determine the desired "look and feel" of the product.

1.   Employ rich cases and examples in a narrative (story) format.
2.   Embed multiple cases in a larger story (*macrocontext*) to sustain exploration across cases.
3.   Use pictures not text to the extent possible.
4.   Have the student provide "story" resolutions before they are exposed to "expert" solutions.
5.   Embed the data needed to solve problems in the learning context.
6.   Support multiple links between concepts across cases. Stress the web-like structure of knowledge across the domain. Use hyperlinks for random access of knowledge.
7.   Present knowledge from multiple perspectives.
8.   Stimulate the collaborative process by presenting problems so complex that students must work together to solve them, i.e., students must socially negotiate problem solving.
9.   Use active learning techniques. Students must do something; they must construct knowledge.
10.   Support continual self-assessment, i.e., self-reflection and articulation of the learning process by the student.
11.   Provide support at critical junctures to push
the student past current limitations, such as introducing information to correct persistent biases.
12.   Expose students to expert performance.
13.   Provide pairs of related stories to establish
learning transfer outside the macrocontext.

As previously mentioned, constructivist instructional environments are difficult to develop. As a result, few examples are available. This proof-of-principle courseware was developed to provide a model tool illustrating how the design principles can be implemented to support advanced military training.

PHASE II: PROOF-OF-PRINCIPLE DESIGN AND DEVELOPMENT PROCESS

The primary training need is to provide a less resource intensive training package for advanced students to engage in higher level cognitive skill-
building before training with a full-scale simulation. An on-screen learning tool was proposed to help the student integrate concepts in a less resource intensive training environment to avoid costly, rudimentary mistakes during simulation training and to increase the level of learning during full-simulation training.

A constructivist multimedia training tool features a collection of independent media objects each with its own set of behaviors. "The whole design paradigm of... constructivist [multimedia computer applications] is based on cause and effect...Working out all the interrelationships [among objects] can get fairly complicated," (Lopuck, 1996, p. 34). As previously stated, an on-screen, constructivist application is not meant to model all the dynamics of a system, but it still requires a concentrated effort to examine the cause and effect relationship among objects used on screen by the student. An object-oriented authoring tool is a natural choice for creation of such a constructivist training tool.

Figure 1. The Student-Centered Learning Process

The proof-of-principle courseware was developed in ToolBook II Instructor™, the U.S. Army's standard authoring tool. ToolBook™ is an object-oriented authoring environment (Asymetrix Learning Systems, Inc., 1997). It is a high-level authoring system, i.e., user friendly for non-programmers. However, it is less capable than low-level programming languages like C or C++ for developing constructivist environments. Using ToolBook™'s mid-level authoring language, OpenScript, with the ToolBook™ tool palette provides more concise control of the programming of objects, and the necessary flexibility for a constructivist title.

We named the proof-of-principle product ACUMEN (Advanced Cognitive Understanding of Military ENvironments) to reflect our goal of providing the first step in the development of swift judgment and keen insight.

During the design and development process, working sessions with key instructors and their senior officers were interspersed with focus groups to

- gain consensus among the instructor-SMEs for the general approach,
- develop the inputs to the product,
- agree on key features to evince each of the design principles,
- and develop the look and feel of the product.

Consensus on a Constructivist Approach

Individual discussions were held with key instructors and their senior officers who had been involved in Phase I of the project. The consensus was to attempt to represent our recommended strategy in a computer-based tool to support residential instruction. The notion of a macrocontext—an overarching scenario—was validated by these key users. They felt that current instruction was not "deep" enough due to the use of a number of unrelated, abstracted cases used for various exercises and teaching points in the course. Their long-term desire for course development was to embed all small group instruction into a rapid, iterative plan-execute-plan cycle. The concept of a macrocontext supported their desired goal.

Our next step was to meet with all instructors to discuss the needs for "deeper" learning in the course and methods to obtain that goal. This focus group was one and one-half hours long.

Instructors were asked to consider how they would create more proficiency and a deeper understanding of the battlefield for the advanced student. We described the constructivist approach as a solution. After a brief discussion, we solicited comments from each individual in turn related to the design principles.

Many instructors felt strongly that students could not learn the art of Fire Support at the higher cognitive levels without face-to-face instruction, group interaction, and exposure to realistic exercise of the skills such as at one of the U.S. Army's Combat Training Centers. We used the meeting as an opportunity to put into perspective the expense of such an approach and the role of the proposed product as a first step toward skill development, not as a replacement for realistic exercise of skills once they are learned.

Training Product Inputs, Key Features and the Look and Feel of the Product

We had used the key elements of the constructivist instructional approach to guide our development of instructional design principles as shown above. We continued to use these principles to guide the remainder of the individual and group sessions. These sessions included highly integrated discussions and decisions regarding training context, key software features, and the general look and feel of the product, but feedback was always related to one or more of the principles to order the discussions.

We created a principle by feature matrix to capture suggestions about design features. We also used flow diagrams and other graphics as well as storyboarding to further capture ideas related to each principle.

Principle 1. Employ rich cases. An existing rich case format was represented in the paper-based vignettes already in use in the course for the three TLOs as noted in the media review above. These three vignettes were implemented in the full-scale simulation, Janus, and the only computer interface for the student was the Janus screen. The existing vignettes were deemed an adequate model for case representation.

Principle 2. Embed cases in an overarching scenario. The vignettes currently in use were not, however, embedded in an overarching scenario or macrocontext. The lack of a macrocontext creates a condition in which a

student or student group cannot engage in sustained exploration of concepts across cases to the degree we believe necessary to practice the higher level cognitive skills that are the focus of this effort—Application, Analysis, Synthesis, and Evaluation. Moving the student through a number of case situations varying in degrees of authenticity does not create the immersive experience necessary to make optimal connections among principles within a domain.

We concluded that a Northeast Asia campaign contained opportunities for sufficient variations in missions to support the actions required in some 14 vignettes we believed would be needed to eventually integrate all the TLOs.

We chose, however, to base the proof-of-principle product on an existing course vignette executed on simulated Fort Irwin, CA terrain to illustrate as many of the design principles as possible within a small demonstration project. Although we did not develop the Northeast Asia campaign for the demonstration project, we did further elaborate the desired macrocontext by specifying at a high level the vertical and horizontal organizational and information connections that would be needed in the overarching context once it was constructed.

Principle 3. Use pictures, not text, to the extent possible. Instructors were concerned primarily about the look and feel of the product. Their standards were very high in terms of realistic solid graphics, graphics animation, and integration of video.

The first element of interest to the instructors was the build up of the vignette. They were interested in the integration of video, specifically use of Cable News Network (CNN) type announcements. They also requested realistic representation of the commander as he expressed his intent or corrected actions during use of the training product. To create the desired effect, we filmed professional actors in a studio reading from scripts we had prepared. To avoid showing the tiny AVI files often seen in training products, we gave the illusion of full screen video by inserting the live actor into a full screen graphic setting.

The instructors and the development team agreed that the product should avoid the look and feel of a productivity tool, e.g., square buttons to access information. For example, our main work screen for the user was a representation of the inside of a vehicle in

which the Fire Support Officer (FSO) would be seated during periods on the job. Instructors wanted the vehicle to contain realistic pictures or renderings of the radios normally available to the FSO, rather than buttons marked "radio." They wanted the radios to have the ability to broadcast so much information as to overwhelm the student as is seen in realistic settings.

Principle 4. Have the student provide "story" resolutions before they are exposed to "expert" solutions. Our concept was for the student to play the role of a Battalion Task Force FSO. The "story resolutions" are in the form of interim and final products that an FSO would actually produce in a field setting.

Principle 5. Embed the data needed to solve problems in the learning context. After examining the vignette, we determined that it would need some modifications to create the desired level of detail. We had to generate additional tactical material to provide the sufficient level of detail envisioned.

Principle 6. Support multiple links among concepts. The product must have a high level of linkage underlying all information available. For example, key words in operations orders were directly linked to maps or execution matrices. As many links as possible were constructed among the various tactical materials and among objects in the environment so that students would be able to create their own paths through the information during each use.

Principle 7. Present knowledge from multiple perspectives. To represent multiple perspectives we provide the student with access to the information he would find in the information records of other staff officers. He must seek the information to access it. Occasionally, we have one of the other officers appear and pose a question to stimulate the need for accessing other perspectives. We also pose challenges to the student that require him to synthesize information across specialty areas and from an enemy perspective.

Principle 8. Stimulate the collaborative process by presenting problems so complex that students must work together to solve them. Collaboration is achieved both by student collaboration with the computer to acquire information and outside the computer when students will be able to consult others in their small group instruction section about the

challenges. If the product is eventually used in a self-study mode by an individual distance learning student, we proposed to establish a "chat room" as part of the FAOAC web site where students can exchange ideas during training.

Principle 9. Use active learning techniques. We wanted to avoid having a student sit at the computer screen in a passive mode. For example, some computer-based training requires students to read large amounts of text or listen to long narration. At all times, the student should be engaged in finding or manipulating information or testing solutions. If large amounts of text are involved, we envision the student printing out references for study or composing text on the computer in an active mode.

Principle 10. Support continual self-assessment. Eventually we plan to refine methods for the student to display his growing understanding through multimedia displays. At present, the student must complete various products that are a part of the FSO job. We are integrating automated assessment checklists so that the student can assess the quality of his work.

Principle 11. Provide support at critical junctures to push the student past current limitations. Specifying the steps in the student-centered learning process provides instructors with a guide to providing facilitation during the learning process.

Principle 12. Expose students to expert performance. We are integrating electronic versions of previous in-class performance with the vignette. The solutions consist of feedback on courses of action and Janus screen displays showing courses of action as they were implemented.

Principle 13. Provide pairs of related stories (vignettes) to learning establish transfer outside the macrocontext. For purposes of this project, we developed one mission (vignette) on Fort Irwin, CA terrain and not in the macrocontext of Northeast Asia. During future development, we will create model vignettes in the Northeast Asia campaign, and this demonstration vignette will become one of the 14 paired cases outside of Northeast Asia.

In summary, we found that the principles could be demonstrated in the proof-of-principle product.

DISCUSSION

To complete development of this experimental product for advanced training, there are three areas in which we need to add to the design: Support for instructor facilitation; cognitive authenticity; and learner motivation.

Instructor Facilitation

A key point for the instructors was how the technology would eventually be introduced. Instructors were very vocal in their opinions of the introduction of technology. The last thing they want is another piece of technology that they do not know how to use. They feel that technology that is introduced into the classroom without support or preparation for instructors results in wasted time and confusion.

Three years of research into the application of situated instruction for children by the Cognition and Technology Group at Vanderbilt University (CTGV) supports this perception. To facilitate teacher effectiveness, the CTGV (1993) found that it was important to introduce simple technologies into classrooms at the beginning of change to a constructivist approach as the teacher is also changing the culture of the classroom at the same time as technology is being introduced. Planning time and technology support were important to avoid losing learning time for students.

In order to support the FAOAC instructor's role in using our product, we must provide more information for his use during the facilitation process. Development of facilitation must be supported by observation of the learning process. Typical mistaken assumptions, overlooked information, and biases must be cataloged to facilitate human and eventually computer-based coaching for the distance student. We must experiment with when and how much feedback to introduce for maximum effect.

Cognitive Authenticity

As previously stated, we were not pursuing fidelity in this proof-of-principle product in terms of a representation of the full-scale dynamics of the battlefield, but we have not yet determined the level of authenticity needed to best engage the student in problem solving. In this instance, instructors were

concerned how the situation is first introduced to the student so that the context seems plausible and engaging, how information was made available to the student, and the form in which feedback was introduced during problem solving.

Matching the level of expertise to the level of authenticity is an empirical question (Jacobson & Spiro, 1994). Young and McNeese (1995) discuss the constructivist learning environment in terms of a "constrained realistic context." While some empirical data have been generated to provide us with an understanding of how these realistic, but constrained contexts can improve learning in children, little data are available about the effects of authenticity to guide the developer of military training.

As a result of this effort, we have come to believe that the key research issue is the establishment of what we are calling *cognitive authenticity*. By this term we mean the emulation of the features that an expert would perceive in a specified domain to support a naturalistic perceptual and decision making process. The achievement of such authenticity is not necessarily dependent on an exact representation of all dynamic features in the natural environment. We are currently investigating the role of various cognitive task analysis procedures to support development of cognitively authentic, constructivist learning environments.

Learner Motivation

Factors of motivation have been culled from the literature (Stoney & Oliver, 1997) which can provide the developer with methods to engage the user without having to create conditions of fidelity. Eight factors identified by Stoney and Oliver are immersion, reflection, flow, collaboration, learner control, curiosity, fantasy, and challenge. In their work, they have produced a model learning tool to create motivation for a course in finance. The model tool was very successful at engaging adult students in a course that they admittedly found dull in a lecture and discussion format. We need to look at how work in the area of motivation factors can inform our design.

Beliefs about the nature of learning may, however, override these factors of motivation. Beliefs seemed to act as a control function over the learning process and influenced post-

instruction performance in experimental uses of a non-linear learning tool (Jacobson & Spiro, 1995) for adults. Students who believed in the web-like structure of knowledge and non-linearity of the learning process benefited most from an experimental, nonlinear learning process. Students who believed that knowledge was or should be imposed from an external source and that knowledge was orderly and linear benefited less from training. We are integrating an examination of interactions of student beliefs about learning with other motivational factors into ongoing development efforts.

In conclusion, as the factors discussed above are more fully developed in the prototype tool, assessment criteria for the factors will be established. We will use these criteria to support user evaluation of the more complete product. A formative user evaluation and analysis will be conducted to determine that the instructional design principles and design factors have been sufficiently demonstrated, that the features work, and that the student can easily navigate within the application. Once these development steps have been completed, a research plan will be derived from the theory to examine the training process and outcomes this product can produce when used as part of the recommended student-centered learning process. Advanced students will participate in future evaluation of the design and the effectiveness of the product.

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Key terms: Constructivism, Cognitive Authenticity, Cognitive Flexibility Theory, Instructional Design, Instructional Technology, Student-centered Learning