Problem-Based Embedded Training: An Instructional Methodology for Embedded Training Using Mixed and Virtual Reality Technologies

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ABSTRACT

In order to meet new readiness goals, military training is becoming more soldier-centric, just-in-time, and embedded within the situations, equipment, and even uniforms that soldiers use. At the same time, newly emerging technologies, such as mixed and virtual reality, offer opportunities to greatly enhance embedded training. These technologies enable the use of powerful simulations that are designed to achieve specific training goals and performance requirements. By using embedded training with these technologies, we have the opportunity to innovate military training and performance support.

Although new technologies bring much promise, current instructional methodologies do not adequately address how to design and deliver training in context of mixed and virtual reality training scenarios, or how to move seamlessly among different types of training. To address this need, we have developed an instructional methodology, problem-based embedded training (PBET), which enables designers to create simulated mixed and virtual reality missions that are geared to meet specific training objectives. This methodology builds from the problem-based learning (PBL) methodology as well as augmented cognition and scaffolding. To validate the methodology, we conducted a heuristic evaluation with five experts in military training and instructional design. In this paper, we present the methodology, example training materials, and results of this heuristic evaluation. This is part of a project funded by the U.S. Army Research Institute for the Behavioral & Social Sciences, Simulator Systems Research Unit (Contract Number DASW01-03-C-0014).

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INTRODUCTION

In the past two decades, there has been a distinct shift in the landscape of military training. Due to new training readiness goals set by the Department of Defense (DoD) (Harris, 2002), along with advances in technologies, there is a need for training that is soldier-centric, contextualized within the learning environment, just-in-time, collaborative, adaptive, and based on newly emerging networked technologies (Bonk & Wisher, 2000). Additionally, training is now expected to be embedded in the equipment and provided on-demand to support job performance

Newly emerging technologies that can help meet these needs are mixed and virtual reality. Mixed reality involves merging real and virtual worlds where real environments or objects are connected with virtual ones. MR-based training environments enable the use of powerful simulations that are contextualized to support specific training goals and missions, settings, and performance requirements. Embedded training using MR has the opportunity to enhance training in variety of environments, from live field training exercises to on-the-job performance support and online or classroom training.

Yet current instructional methodologies do not adequately address how to design training using mixed and virtual reality environments or how to move seamlessly between these modalities in the instructional environment. This requires new models of instructional design that are learner-centered, flexible, modular, adaptive to soldiers' needs, and that facilitate the use of new technologies for training and job performance.

To meet the need for an instructional methodology for embedded training using mixed and virtual reality, we have developed problem-based embedded training (PBET). Based on problem-based learning (PBL) (Barrows, 1992; Savery & Duffy, 1996), the PBET methodology enables designers to create simulated mixed and virtual reality training scenarios and missions geared to meet specific training goals. In this paper, we present the PBET methodology, sample training materials, and results of a heuristic evaluation of the methodology performed by military training and instructional designers experts.

EMBEDDED TRAINING USING MIXED AND VIRTUAL REALITY TECHNOLOGIES

Over the next ten years, the U.S. Army will roll out its transformational Future Combat Systems Family of Systems. These programs will introduce radically new technologies to the field (Welch, 2003). Within this first increment, a family of manned systems will provide tomorrow's soldier with high battlefield mobility and unprecedented organic reconnaissance and surveillance capabilities. These systems will all require the development of embedded training and performance support systems during the systems acquisition process (Embedded Training Definition for the Objective Force, 2003). These integrated development programs offer exciting possibilities for placing the control of sophisticated training technologies into the hands of soldiers and their immediate training supervisors. These training technologies potentially enable always-on access to embedded training, assessment, and control of exercises on the operational equipment with auxiliary equipment and data sources as necessary (OFW, 2003).

To address the needs of embedded training approaches, mixed and virtual reality technologies are seen as providing promising ways to provide more authentic and complex training environments through the *enhancement of reality*.

[1] The opinions expressed are those of the authors, and do not represent an official position of the U.S. Army, the U.S. Army Research Institute for the Behavioral and Social Sciences, or the U.S. Government.

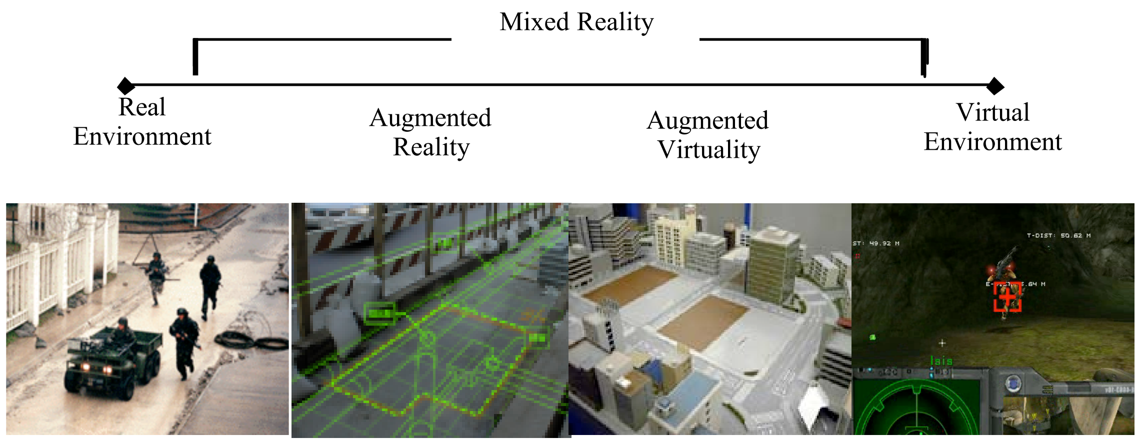

Figure 1. An Illustration of Milgram, Takemura, Utsumi, & Kishino's (1994) Mixed Reality Continuum (S. Kirkley, 2003).

Figure 1 demonstrates the continuum of reality and virtuality as described by Milgram et al (1994) and provides some examples of how these technologies may be potentially applied to support training and performance support. At the far right, the virtual environment is used in both immersive and desktop simulations. In the middle sections, augmented reality and augmented virtuality, or mixed reality, are combinations of virtual and real world environments. Augmented reality enhances the user's real world with computer-generated images, text, sounds and touch. This example shows the location of underground utilities beneath a street repair project. Augmented virtuality is primarily a virtual reality environment onto which real objects are inserted. Here, 3D virtual models of planned buildings are superimposed on an architectural layout.

While these training technologies can be used with a variety of methodological frameworks, we have specifically adapted problem-based learning as a methodology to support embedded training using mixed and virtual reality technologies. This methodology and the evaluation of this methodology are presented in this paper.

DEVELOPING THE PBET METHODOLOGY

In order to determine which methodology would fit well with embedded training using mixed realities, we went through the following processes:

- Created a list of characteristics of the Army training environment based on new training directions (e.g., soldier-centric, contextualized within the learning environment, just-in-time, collaborative, adaptive, and based on new technologies).
- Conducted literature reviews on: 1) use of training in mixed and virtual reality environments; 2) embedded training approaches; and 3) use of simulations to support military training.
- Developed a list of possible instructional methodologies that would match the characteristics of the training environment and support the use of mixed and virtual reality technologies, such as problem-based learning (Barrows, 1992), case-based learning (Reisbeck & Schank, 1989), and anchored instruction (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990).
- Examined methodologies in light of training environment characteristics and information on mixed and virtual reality technologies. We then identified PBL as a methodology would work well to support embedded training using mixed and virtual realities in embedded training.
- Adapted PBL specifically to support embedded training environment using mixed and virtual reality technologies.

While problem-based learning (Barrows, 1992; Savery & Duffy, 1996) was chosen as the methodology for maximizing the effectiveness of embedded training using mixed and virtual technologies, the use of other methodologies to support embedded training is precluded. However, the advantages of PBL in this case, as detailed in the following section, provided a strong rationale for using it as a model for creating problem based embedded training (PBET).

PBL was chosen as a methodology for a variety of reasons. First, it provides a systematic process for designing instruction that focuses on complex and authentic real world problems and situations. This is of value in military training environments where application of knowledge and skill is needed to address multiple ill-structured challenges within a variety of training scenarios.

Second, PBL matches well with Army training, where problem solving approaches are valued, particularly for field training exercises. However, for such exercises, there is not always a specified process for designing instruction.

Third, PBL has been widely implemented and researched in a variety of educational arenas, including medical, engineering, and business education (Barrows, 1992; Milter & Stinson, 1996; Woods, 1992) as well as some K-12 and undergraduate educational environments. From research reviews on the use of PBL (e.g., Albanese & Mitchell, 1993; Vernon & Blake, 1993), we have an understanding of some of the outcomes of using PBL. In these research reviews, it was found that PBL often promotes: self-directed learning, use of learning resources, and problem solving and critical thinking skills, which includes there sometimes being less content coverage in PBL curriculums as compared with traditional curriculums, and some groups of students using PBL did not score as high on standardized tests as students in more traditional curricula (see Albanese & Mitchell, 1993, for more discussion). However, both types of outcomes would need further examination in light of any implementation of the PBET methodology.

Fourth, PBL is a theoretically grounded methodology, which means there are documented linkages among research, theory, and practice of PBL. This means that there is a fairly consistent understanding of the PBL methodology. It is important to clarify that the theoretical model of PBL used in the United States has primarily been based in constructivist learning theory, although some European universities use a more cognitive-based model. With the cognitive model, there is an emphasis on using students' prior knowledge and elaboration to ground the learning process (Schmidt 1993). With a constructivist model, the goal of PBL is to support the learner's authentic engagement in an issue that is a legitimate and central issue in the discipline. Thus, the key goals of PBL is to support learning the ability of learners to generate hypotheses, gather information to evaluate the hypotheses, and discuss and defend a perspective (Duffy and Cunningham, 1996).

It is important to note that in the PBET methodology, is being used to design embedded training using mixed and virtual reality technologies. While this impacts the design of the training environments, it does not dictate the choice of PBL as a methodological commitment.

In order to extend and adapt the PBL methodology, we used the Savery and Duffy (1996) instructional principles of PBL as a starting point:

1. Anchor all learning activities to a larger problem.
2. Design an authentic task.
3. Design the learning environment to reflect the complexity of the environment in which the learner should be able to function at the end of learning.
4. Support the learner in developing ownership for the overall problem.
5. Design the learning environment to support and challenge the learner's thinking.
6. Encourage testing ideas against alternative views and alternative contexts.
7. Provide opportunity for and support reflection on both the content learned and the learning process.

These principles, explained in more detail in their article, provide the foundation for the development of the PBET methodology. Along with these principles, the following design assumptions were also considered:

- The primary emphasis is on embedded training, which means that training is embedded within the context, environment, and equipment that soldiers use. Hence, the PBET approach can support the systematic design of a wide range of training contexts and needs (e.g., embedded equipment training, strategies, and tactics).
- The PBET methodology is a holistic methodology for designing training in general, and not just that using mixed and virtual reality technologies. Not all training goals need to be met through use of the high-end technologies. Guidance on understanding when and how to use these technologies appropriately and effectively is a critical issue for designers and an important research issue.
- Flexible delivery of instruction is critical. Mobile computers (e.g., handhelds, tablet, or laptop computers), head-worn displays, and combat crew vehicle workstations are increasingly being used for training. Thus, inputs and outputs should be multimodal and include audio, visual, and haptics.
- Using the PBET methodology does not negate the use of traditional instructional techniques such as memorizing procedural tasks or practicing skills as long as the end goal of the instruction is to use the knowledge to solve an authentic problem or set of problems.
- Since PBET can be used in a range of training situations, it must be modular and adaptive to meet a variety of needs. By using learning modules and shareable content objects (SCOs) as resources within a PBET mission, PBET can provide an integrated learning and performance support environment.
- PBET builds on models of situated learning, augmented cognition and scaffolding (Hannafin, Land, & Oliver, 1999) as well as methods of

designing performance systems (Gery, 1991). In order to support embedded scaffolding, a performance support system will be a critical element for facilitating the PBET instructional materials. An expert system will provide intelligent tutoring supports and track individual training needs and achievements. Of course, this does not negate the need for human scaffolding via facilitation, coaching, and telementoring.

- The PBET methodology uses a range of assessment methods. First, the Army's model for After Action Review (AAR) is used as a core piece of the assessment. Knerr & Lampton (2002) describe the DIVAARS system where interactions in the field can be captured and examined for lessons learned. This is an important advantage of Second, embedded assessment (Champagne, 2003) and performance-based testing (Linn, Baker, & Dunbar, 1991) are both used to guide evaluation methods. Embedded assessment provides support for learners during the learning process as well as providing information on the effectiveness of the instruction to instructors/trainers/designers.

Development of the PBET instructional model is based on two implementations of online problem-based types of learning environments: the Learning to Teach with Technology Studio (see Malopinsky, Kirkley, & Duffy, 2002); and the AMIGO system (see Bransford, Vye, Bateman, Brophy, & Roselli, 2003).

The PBET instructional model includes four main components:

1. Mission
2. Action Plan
3. Implementation
4. After Action Review

Although process appears to be linear, the goal is for learners to go through the stages based on the specific learning progressions and goals based on individual and group needs as well as overall training goals

Figure 2: Overview of PBET Instructional Model

CREATING THE PBET TRAINING SCENARIO

To develop the PBET scenario and training module, we used Wiggins and McTigue's (1999) backwards design process. With this approach, desired learning outcomes and evidence are identified first and only then are learning activities are developed.

The subject matter of this training scenario and module was on learning strategies for using and managing unmanned robots for reconnaissance. Note that this scenario was designed for an infantry squad of nine soldiers, comprised of two fire teams working together.

1. Mission (and Training Goals)

The Mission is the core part of a PBET model. It is an ill-structured *problem* that the soldier or a squad addresses (collectively and individually). The mission grounds the learner in an authentic situation that reflects real life complexity and is designed to support meeting learning goals.

Before the Mission was written, the specific training outcomes and goals were identified (e.g., a list of sample goals are listed below).

PBET Example:
<u>Training Goals</u>

1.0- Navigate as a Fire Team with Robots

1.1 Soldiers can successfully determine their intended route(s), and develop contingency plans to cope with unexpected obstacles.

1.2 Soldiers can successfully employ unmanned ground vehicles (UGVs) to support squad mission.

2.0 Cover and Concealment

2.1 Soldiers maintain proper sound, light, and litter discipline.

2.2 Soldiers successfully plan for and respond to enemy action (e.g., snipers) and obstacles (e.g., mines), while avoiding typical mistakes that result in injury from enemy fire, mines, and booby traps.

3.0 Robotics and Sensor Integration

3.1 Soldiers can analyze and choose the best strategies for deploying robots in order to conduct reconnaissance and get the most information on a route.

3.2 Soldiers can successfully coordinate with robots to obtain new/updated information on obstacles as well as possible positions for cover and concealment.

Following is the Mission that supports achieving this goal.

<u>*PBET Example:*</u>

<u>**Mission**</u>

Your squad's mission is to conduct a recon in sector and clear remaining elements of the enemy in order to set up a secure company team command post. To help you accomplish this mission, you have been assigned a SUAV (small unmanned air vehicle) and a UGV to help with recon work, along with support from battalion UAV assets. Use the robots to help you avoid land mines, identify enemy locations, and to obtain recon data on the area.

It is important to note two specific aspects of the Mission statement. First, the Mission is written specifically for the soldiers and units doing the training and not as a fictional representation (e.g., pretend you are in battle). In general, missions should be as written to be as authentic as possible and based on real world situations and scenarios. Second, the same training goals may appear in multiple missions or training modules in order to provide multiple opportunities for practice or understanding of the goal in different contexts (e.g., cover and concealment in a desert versus forest) or to meet individual training goals based on specific job assignment or knowledge gaps. This criss-crossing the landscape provides the opportunity to learn things from multiple perspectives, thus increasing flexibility in knowledge application (Spiro & Jehng, 1990). Curricular planning (e.g. developing sets of problems to address a core set of goals) as well as individualized customization of training can be used to address these issues.

Second, it is critical that the Mission be designed to support soldiers in achieving the specific training goals and outcomes specified in the module. This often requires careful crafting of the Mission statement so that it is clearly focused on facilitating the achievement of training goals.

To develop the Mission scenario, we used rapid prototyping techniques (Tripp & Bichelmeyer, 1990) to storyboard possible actions and strategies that would be addressed. First, we created a storyboard using images presented in PowerPoint. After refining the possible actions in a scenario, we then developed a second prototype using a gaming engine (see Figure 3). (Note that the scenario created was intended to demonstrate possibilities rather than current operational doctrine or predicted doctrine at OFW initial operational capability.) The use of the gaming engine as a rapid prototyping technique enabled us to efficiently demonstrate possible sequences and interactions in an augmented reality environment that would not possible using just images or video. However, it takes time to model objects and to program possible movements, so simple drawings and storyboards are recommended for initial prototyping. Interestingly, this simulated AR training scenario could be used as a desktop simulation where soldiers could try out different strategies or practice specific skills before getting into the AR training environment.

Figure 3. This AR training scenario demonstrates one soldier's perspective. While the building exists in reality, the SUAV (see video fee in lower right corner), the landmines, and opposing forces are digital.

2. Action Plan (Problem Solving Approach)

Within the traditional approach to PBL, a structured approach is usually not provided. However, the PBET methodology does provide a structured and scaffolded approach for solving the problem. While traditional PBL depends on a trained facilitator to guide the learning process, the PBET training will occur in a wide variety of contexts which may or may not include a facilitator: individual self study; online collaboration, classroom-based training, field-based training, and even on-the-job performance support. It is assumed that for group-based complex training events, a facilitator's support will probably be a requirement.

<u>*PBET Example:*</u>

Action Plan

- ***Action 1:*** *Analyze and choose the best strategies for deploying robots in order to conduct reconnaissance and get the most information on a route.*
- ***Action 2:*** *Coordinate with robots to get new and updated info on obstacles as well as possible cover and concealment positions*
- ***Action3:*** *Coordinate squad movement*
- ***Action 4:*** *Develop movement and contingency plans.*
- ***Action 5:*** *Set up defensive perimeter, clear building, and secure it.*

In order to help soldiers address the Mission, guided instruction, tools, strategies, and other elements will be provided with each Action item.

To provide guidance, each Action Plan contains many of the following elements:

- **Learning objects,** such as simulations or demonstrations that the trainer, soldier, or team can use to support learning and practice.
- **Expert guidance** through either coaching or best-practice scenarios, presented via recorded interviews, scenarios, or remote mentoring.
- **Basic resources,** such as online interactive Army field manuals.
- **Performance support tools,** such as and checklists provide on-the-job support.
- **Embedded assessments** that enable the soldier and training unit test personal learning as well as training effectiveness (Champagne, 2003).
- **Individualized guidance** based on soldier expertise, training goals, and job assignment.
- **Scaffolding elements** (e.g., job aids, hints) to support soldiers training for mixed or virtual reality-based field exercises, as well as for classroom or online learning.

Specifically, providing appropriate and effective scaffolding will be critical in this environment. Scaffolding, defined as supports for students in attaining a higher level of understanding beyond their current capabilities (Hannafin, Land, & Oliver, 1999; Vygotsky, 1978), will provide ways to understand concepts, procedures, strategies and metacognitive issues. To address the need for scaffolding, we have begun development of a scaffolding framework for the PBET model, using Hannafin, Land & Oliver's (1999) framework as a starting point. Their framework describes four types of scaffolding: conceptual, procedural, metacognitive, and strategic. In future development, we plan to expand this framework to include physical (e.g., hands on), as well as other types of scaffolds.

Given the many elements within the Action Plan tasks, an expert system would be needed to deliver many of these components based on individual soldier and unit needs or requests. Such a system would be able to enhance personalization of learning for each soldier and help him or her evaluate personal effectiveness.

3. Implementation

In this stage of the model, the soldier or squad uses what has been learned and created in the Action Plan to address the overall Mission Implementation. There are two parts to the implementation: 1) mission rehearsal and 2) field-based implementation. The mission rehearsal provides an opportunity for soldiers to try out their solution to see how well it works. It also provides them with an opportunity to go back to the Action Plan or other training resources in order to improve learning or performance. The Implementation deliverable may be participation in a field training exercise, an on-the-job performance task, or production of a unit training report. It is assumed that individual soldiers as well as teams will be evaluated during this part of the module, so appropriate team performance rubrics are relevant.

<u>PBET Example</u>:
In this training exercise, the squad will demonstrate its plan to accomplish the Mission in an augmented reality-based field environment (see Figure 4).

Figure 4. The augmented reality-based training scenario depicts the leader of a fire team employing an organic UGV and a SUAV to scan for land mines (blue area on left). Note that video feed of scan from UAV is in lower right corner.

4. After Action Review (AAR)

This stage provides a series of assessments for units and soldiers, structured as a reflection on what was learned and how it fits in with other missions or training goals (individual or collective) or as a performance review. Typically, the AAR will include product and performance assessments for units and individuals. The AAR process conforms to Army doctrine. In a mixed or virtual reality-based training environment, actions and events could be recorded by a specifically designed system, such as the Dismounted Infantry Virtual After Action Review System or DIVAARS facilitate the access of and examination of training episodes for review and assessment of individual as well as team performance.

Embedded assessment (Champagne, 2003) in the system will enable soldiers to evaluate the design of the mission as well as the quality of the elements of instruction. The results can be compiled and analyzed so that missions or instruction can be revised or updated as needed, based on data from assessment performance as well as soldier input.

EVALUATION METHODS

In order to validate the PBET methodology, we conducted a heuristic evaluation (Neilsen & Molich, 1990) with several experts in instructional design and assessment and military training and simulations. The overall goal of the evaluation was to validate the PBET methodology as an effective approach for embedded training using mixed and virtual realities.

Five experts participated in the evaluation: three evaluators had expertise in instructional design (each with sub specialties in simulations, problem-based learning, and assessment); one evaluator had expertise in military simulations; and the remaining evaluator had expertise in training the use of unmanned ground vehicles in military operations (the focus of the training module).

As part of the process, each evaluator received the following materials:

- Paper detailing the PBET methodology;
- A text format of the instructional model using the PBET module and a list of design assumptions;
- Videotape of a simulated augmented reality-based training scenario (see Figures 3 and 4).

Each evaluator used an evaluation form to guide the review of the PBET methodology and training materials. The form contained survey and open-ended questions relating to the methodology, as well as how it was implemented in the design of the training module and scenario. Each evaluator rated the PBET methodology in terms of:

- Effectiveness of embedded training in mixed and virtual reality technologies;
- Effectiveness for supporting mixed and virtual reality-based training;
- Innovation as a way to meet future goals for military training;
- Appropriate linkages to research and theory;
- Approach for supporting training and performance for predicted OFW training requirements.

All five evaluators completed the evaluation form. The results of the evaluation are discussed in the following section.

RESULTS

Following are results of the evaluation of the PBET methodology. The discussion focuses on the following key areas:

- Effectiveness of the PBET approach
- Need for scaffolding and opportunities for practice and repetition
- Importance of reality and complexity in the embedded training environment
- Design of AAR and performance assessments
- Relationship to OFW training.

Effectiveness of the PBET Approach

From the evaluation results, all five evaluators stated that the PBET approach had the potential to be a useful and effective method for supporting embedded training using mixed and virtual reality technologies. One evaluator stated that PBET would reinforce problem solving abilities, support complex, authentic interactions with robots, and support participation in authentic learning environments that are more closely linked to real world situations. Following are several evaluator comments:

- [PBET] offers a path to a more authentic training environment. The situations encountered and the sequence of decision-making more accurately match the sequence found in actual situations…

- If designed properly, the PBET system should allow soldiers to become more efficient in interfacing with robotic systems and help them to develop proper usage of their OFW ensembles.

- Allowing soldiers to learn in virtual environments that simulate the real world should prove to be both motivating and highly effective. When they have to go into battle, the soldiers will be well practiced.

Evaluators were asked to list some potential disadvantages they see with the PBET methodology. One evaluator noted that some specific drawbacks to PBL were already discussed in the PBET methodology paper (e.g., less time for content coverage), and that these points need to be addressed with regard to how to overcome or compensate for them in the design of training. Another evaluator noted her concern with cost and complexity of developing PBET training, noting that it could be justified with better in-field performance.

With regard to the specific aspects of the PBET instructional module and augmented reality training scenario, evaluators felt that the training goals were made explicit. Although one evaluator stated that training outcomes were clear, she said she would not be sure how to structure training across missions. Another evaluator stated, "Your design is solid. PBET is more performance-based and specifically focuses on decisions the soldier must make in the field." Another evaluator stated that the section on the PBET framework was easy to read and follow. However, one evaluator was concerned that the PBET methodology did not provide flexibility to missions and was concerned that the instruction may possibly limit what can be done in a mission.

Importance of Approaching Complexity of Reality in Embedded Training Environments

All five evaluators stated the need for the mixed and virtual reality training environments to replicate the same situations (e.g., battlefield conditions) and tools used in real world situations.

- If the lesson plans/programs are not consistent with real world situations, the risk to soldiers may be catastrophic…

In fact, with regard to the augmented reality-based training scenario, three evaluators stated that the example training scenario needed more complexity in the training environment. (This was due to limitations of the gaming engine used for prototyping.) One stated that the example scenario was fairly controlled and static, which is not typical of battlefield conditions. Another evaluator noted the expectations of today's soldiers, who often have expertise in sophisticated video games. It is important to note that simplified training designs are often advocated as a way to structure the learning process. However, if a soldier does not have an opportunity to experience realistic and authentic situations, the training will be limited. Thus, the evaluators have contributed an important design criterion for embedded virtual and mixed reality types of learning environments – that of complexity and authenticity.

Need for Scaffolding and Refinement of Skills

All five evaluators stated that the examples of scaffolding presented in the PBET module were effective. The scaffolding examples consisted of a job aid and an audio coaching. One evaluator stated there was potential and need for much more scaffolding (e.g., beginning versus expert). Almost all evaluators agreed on the need for scaffolding to match the wide array of levels of expertise, based on the soldiers' training needs as well as team based performances.

Scaffolding is a key area in PBET where there must be design success. To address this issue, the research team is developing a scaffolding taxonomy with different types and levels of scaffolding to support embedded training in mixed and virtual reality environments, including scaffolding for mixed and virtual reality field exercises as well as classroom or online scaffolding.

Three of the evaluators noted the need and place for soldiers to be able to repeat and refine tasks and approaches within the PBET training environment. One evaluator stated that it was important for soldiers to be able to refine their Mission Plan after receiving feedback on their Mission rehearsal.

With regard to having opportunities for traditional training approaches in the PBET environment, it is important to note that the authors of this paper advocate using a variety of teaching strategies as long as they are consistent with the purpose, values, and outcomes of the learning environment. There are often misconceptions that only certain types of training strategies (e.g., problem solving) can be used to teach everything or that certain types of strategies cannot be used (e.g., lecture). For learning to be effective, the focus should be on how the training strategy supports the soldier in effectively solving the problem and meeting the training goals stated.

Design of AAR and Performance Assessment

Most evaluators stated that the AAR process within the described PBET environment appeared to follow the Army's AAR doctrine.

- I like the AAR questions – the first one, particularly, seems like it could be used to assess whether a soldier is ready for the next level or whether more work at this level is necessary. For example, if a soldier is not attending to the most critical aspects of the operation, more work is likely needed.

One evaluator noted that the AAR as described would require a trained facilitator to continually guide the soldiers to a conclusion. This is in line with the authors' vision of how the AAR environment will be most effective. However, there are instances (e.g., self study or practice mode) where soldiers will need tools to evaluate their own performance.

Several evaluators noted the critical need for well-designed reflection assessment processes. One common question that evaluators had was how would performance as both process and product be measured during the exercise. Also, several questioned how to capture data that was not evident during the problem solving process (e.g., metacognitive activities).

- One danger I see is that one might think the learning is taking place due to an appropriate decision made, where in fact the soldier guessed, reacted instinctively, or thought that was the only option. Assessment must be in place to test the metacognition of the learner to assure learning. Otherwise the soldier may not respond appropriately if the reality of combat does not match the simulation where learning took place.

One evaluator with expertise in embedded assessment stated that the embedded assessment examples provided in the module were important for helping gather and organize questions for the AAR.

Relationship to OFW Training

Four of the five evaluators stated that they agreed that the PBET approach would support goals of OFW program. The evaluator who disagreed felt that the methodology still needed some work in order to meet that goal.

-In considering OFW training needs and opportunities, it occurred to me that there are different kinds of skills that would require different types of training approaches. Skills range from instrument operation and survival skills to analysis and decision- making skills. These are all appropriate PBET activities.

This is an interesting statement that nicely illustrates how the PBET approach can serve as a way of framing the holistic training process to help soldiers meet a range of outcomes and goals, from equipment training to tactical operations. By building on training that is embedded not only in situations but job and equipment as well, we can support soldiers in obtaining sophisticated performance skills.

CONCLUSIONS

In summary, the evaluation yielded the following results. The PBET methodology, if well implemented, was considered an effective methodology for supporting embedded training using mixed or virtual reality technologies.

Evaluators noted the importance of and need for:

- providing scaffolding that is designed for a wide range of soldiers' job descriptions and experience levels
- matching training contexts as closely as possible with real world situations, scenarios, and equipment
- providing training with appropriate complexity and authenticity matching needs, skills, and motivations of today's soldiers
- designing assessments that support the learning and reflection, process and product, and metacognitive skills.

This evaluation research was valuable in that it provided validation for the PBET methodology as a viable approach to supporting embedded training with mixed and virtual reality technologies. PBET supports training that is contextualized, just-in-time, collaborative, adaptive, and that takes advantage of the power of emerging mixed and virtual reality training technologies.

There is much research and development to be done in this area. This evaluation only scratches the surface of possible issues to consider in designing these types of mixed and virtual learning environments. However, we look forward to future efforts (ours as well as that of others) in using new technologies to develop and implement innovative training approaches in the military and beyond.

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