A DECISION TOOL FOR MAKING TRADE-OFFS IN MULTIMEDIA BASED TRAINING

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ABSTRACT

The evolving technologies of computers, communications, and digital hypermedia have provided new vistas for the design of learning environments. Multimedia presentations can be used, for example, with video, high resolution graphics, and animation to allow a student to better visualize physical and logical events, as well as relationships among phenomena and parts of a system, equipment or problem. However, with all that functionality and potential gain comes a hardware and software technology that has advanced faster than the instructional technology decision aids needed to support multimedia learning environments. In particular, there is a significant lack of tools to support the decision making needed for analyzing multimedia options and conducting trade-offs to decide optimum solutions. Those solutions must not only be based on sound principles, theoretically framed and empirically validated, of cognition, learning and pedagogy but also must consider parameters of cost, benefits, logistics and infrastructure to make the learning system viable. A tool that has intelligence to automate support of trade-off decisions for multimedia instruction is needed to ensure proper return on investment.

The work to be described was completed under a Small Business Innovation Research contract, Phase I, and was formulated with the objective of defining a basis for the Phase II development and fielding of a computer based tool for performing trade studies on multimedia. The Phase I effort focused on specification of an intelligent tool that guides practitioners, whatever their level of instructional and media technology or content domain expertise, through the analysis process to determine and document how, when and for whom the multimedia can be used, its logistic impact, life-cycle parameters, and estimated costs/benefits.

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THE NEED

The evolving technologies of computers, communications, and digital media have provided new vistas for the design of learning environments. Multimedia presentations can be used with video, high resolution graphics, and animation to allow a student to better visualize physical and logical events, as well as relationships among phenomena and parts of a system, equipment or problem. Greater interactive involvement of both students and those that manage and present instruction is made possible. Instructors can have an immensely more efficient facility to monitor student understanding and activities as well as manage the learning environment and specific media/method events. However, with all that functionality and potential comes a hardware and software technology that has advanced faster than the instructional technology needed to support multimedia learning environments.

In particular, we see the problem to be one of a significant lack of tools to support the decision making needed for analyzing multimedia options and conducting trade-offs to arrive at the best solutions for that case of training. We argue that to make the multimedia learning system viable those solutions must not only be based on sound principles, theoretically framed and empirically validated, of cognition, learning and pedagogy but also must consider parameters of cost, benefits, logistics and infrastructure. Furthermore, since there are unlikely to be many, if any, situations where resources are so plentiful that no questions of how to proceed are raised we must find ways to balance factors that are not all attainable at the same time. Thus, we make training multimedia trade-offs. NAWCTSD has recognized the problem by initiating the project discussed in this paper and the Training Delivery Assessment Model (TRADAM), also discussed at the conference. TRADAM provides a quick assessment of the potential for resource savings through implementation of advanced training delivery technologies

PHASE I SBIR RESULTS

The final product of this Small Business Innovation Research (SBIR) Phase I effort was the functional specifications for an Interactive Multimedia Instruction Trade-off Tool (IMITT). The purpose of the functional specifications is to simply and concisely provide a description of the system, application, or function, and state the implications for human computer interface (HCI) based on the requirements analysis. The functional specifications identify the requirement for an intelligent interface to coach the user and minimize user expertise in technology, trade-offs analysis, and cost/benefits analysis. The tool must support planning and analysis at all levels within an organization as well as the coordination among the levels. Therefore, groupware features are incorporated into the specifications.

The specifications are organized into the following functional requirement areas:

- 1.0 Human Computer Interface
- 2.0 Interface with Other DOD Systems
- 3.0 Problem Definition
- 4.0 Baseline Training Setting
- 5.0 Multimedia Learning Effectiveness Analysis
- 6.0 Multimedia Development Requirements
- 7.0 Multimedia Technology Assessment
- 8.0 Multimedia Development and Delivery System Alternatives
- 9.0 Infrastructure, Logistical Support, and Personnel Requirements
- 10.0 Costs/Benefits Analysis

The functional specifications were designed to be a working document for the Phase II software development and quality assurance team to use. The specifications will be updated as necessary during the IMITT design and development effort. In the remainder of the paper we will briefly summarize the specifications.

SYSTEM CONCEPT

A tool that has intelligence to automate support of management decision functions for multimedia instruction is needed. By intelligent, we mean tools that enhance the performance of practitioners because they contain the knowledge (information, logic, processing capability) to coach and support the user with wizards, diagnostics, hints, and examples. By intelligent, we mean that the tools should learn about the user and adapt the interface accordingly. We do not mean to imply use of artificial intelligent techniques.

We see a need to use the tool at several points in the life-cycle of a training program. There is a need for the tool to be used for both newly emerging systems where a detailed syllabus and learning objectives do not exist yet and for existing, mature programs in which it is necessary to save dollars while keeping the level of training at least of the same quality.

We also think that the tool must support users at several levels including both at the schoolhouse where specific questions of where, how and for who multimedia can be effective might be asked as well as for users who ask strategic planning questions about the introduction of multimedia technology to reach organizational objectives and still live within real-world constraints. Thus, the tool is intended for use by training practitioners, as well as policy makers, budget managers, and the many support agents for operation and maintenance of training. Furthermore, such planning may go on at several levels in an organization. It is our intent to build the tools to support such planning and analysis at all levels and to support coordination among the levels.

We expect that the final product will be a combination of a CD-ROM of stable or relatively stable information and programs integrated with a web site that takes advantage of distributed object technology so that the clients can be updated in a timely fashion from the server. Further, other Internet/Intranet technology is expected to be incorporated for communications and collaboration and to be integrated with the trade-off tools.

This concept is based on a user-centered design approach. We focused on meeting the needs of the decision makers in reaching their goals. We think that the tools will have users with a broad spectrum of backgrounds including enlisted and officer personnel whose usual job is something else. The interface must be designed to meet the experience, mental models and expectations of such users. We also have a view that the user will be a learner of how to use the tools, what trade-off questions to ask, what the technology offers as a mediator of learning, and the practical aspects of acquisition and implementation. Users may also not be experts in interactive multimedia or the constraints and features of electronic learning devices such as large displays and other relevant technology trends and factors. The interface must treat them as learners, when that is appropriate, about topics such as networked computing, multimedia technology, training system acquisition, and multimedia courseware development and application.

We assume there will be varying levels of expertise among users. Thus, we plan to have several forms of learning support from which the user can select. We think that support consisting of brief tutorials on multimedia technology topics should be available. In addition, we intend to provide a Frequently Asked Questions (FAQ) feature, examples and case descriptions, and a help function with a glossary. We envision all of these to be hyperlinked to the decision functions so that a user can explore the trade-off tools beginning within the context of these learner support features. Of course, more advanced users, or those whose preference is just to dive in, can go directly to work with the decision tools. In addition, coaches, similar to Wizards, will be incorporated to adapt the process to the using group, or individual, and the problem at hand while guiding the users through to solutions.

IMITT should automate much of the users work in asking questions, accessing data, and generating reports for either on-screen display or hard copy output. Functions for costing, defining logistics support, and making trade-offs among these factors will be included. The user will also have the capability to copy and paste portions of the data bases, query responses, and trade-off data to a shared work space that can be transferred to another application such as a word processor or spreadsheet program. A multimedia technology database, to be kept current and reflect the state-of-the-art, will be included.

In addition, the software will be designed to support collaboration among decision makers; some of whom may be dispersed in other locations. Collaboration support should include sharing the workspace and possibly other files and computer mediated communication such as forums and e-mail.

DEFINING MULTIMEDIA

The definition of multimedia is of importance because it directly influences how trade-offs may be formulated. The definition itself influences how multimedia instruction is designed and, therefore, the development and delivery systems needed, along with the associated logistics and infrastructure required to support the hardware, software and personnel. Four important components of the definition to be used here will be discussed:

1. the emphasis is on the **multimodal nature** of the learning environment as opposed to the multimedia per se,
2. the emphasis is on the **learner s cognitive processes** and constraints to those processes, as well as the behavioral elements usually attended to by instructors and instructional designers,
3. the emphasis is on the **learner s interaction** with the multimodal learning environment from a cognitive viewpoint as well as the behavioral elements usually defined for interactivity.
4. the emphasis is on **digital multimedia and emerging technologies**, as opposed or compared to the use of traditional, analog multimedia forms (e.g., paper-based, films, videotape, television) or even digital forms of CBT in the past.

Current Military Definitions.

To clarify these points further they will be compared and contrasted with current definitions found in military guidelines. There is no intent to replace those existing definitions. The intent is to complement and extend those definitions to include a view of multimodal learning that is a function of the learners cognitive as well as behavioral interactions with the multimodal instruction. The definition of Interactive Multimedia Instruction (IMI) in MIL-HDBK-1379-3, Development of Interactive Multimedia Instruction, is: “Interactive Multimedia Instruction is a group of computer based training and training support products. Interactive Multimedia Instruction includes source materials that are commonly used in Interactive Multimedia Instruction products, electronic products used in the delivery of or supporting the delivery of instruction and software management tools used to support instructional programs” (page 5).

Multimodal Learning.

Multimodal is defined here based on work done by several researchers in instructional psychology and technology. As defined by Mayer (1996), it is useful to distinguish among the terms delivery media, presentation modes and sensory modalities. Delivery media are the physical systems used to present instruction. Examples of delivery media are books and CBT. Presentation modes are the formats used to represent the instructional content such as printed words, illustrations, animations, and oral narratives. Sensory modality is the information processing channel that a learner uses to process the information. Sensory modalities include acoustic, visual, haptic, and olfactory information processing. An example of these distinctions can be seen when considering that instruction on how equipment works can be delivered via text in a book or on a computer screen (two different delivery media), in the form of an illustration or series of illustrations or in the form of printed statements (two different presentation modes) and as printed (visual) or spoken (aural) words (two different sensory modalities). Current military training definitions focus on delivery systems with recognition of presentation modes but do not include an emphasis on sensory modality as defined here.

Cognitive Processing and Sensory Modalities.

With regard to the question of cognitive processes we are adding sensory modality specifically to invoke the role of cognitive processing of the information in those modalities. It is appropriate, in fact, to think of multimedia instruction as multimodal instruction. We fully recognize that current military training guidelines call for identification of sensory stimulus requirements necessary to support learning objective instruction. This is appropriate. However, we are proposing to extend the implications by identifying the cognitive processes associated with those sensory stimuli. The sensory stimuli should not be identified only by the job task elements, but also by both the learning outcomes expected and the associated processing of multimodal instruction that will occur. What modalities will be selected and in what mix are a function of the cognitive processing expected. These cognitive processes will vary because different modalities are encoded and organized differently. The importance of this will become more apparent in the discussion of theory and research to come. As expressed by one researcher, Iran-Nejad (1990), "I believe the first step toward understanding the multisource nature of learning is to take seriously the fact that the human internal construction system is multimodal."

Learner Interactions with Media, Methods, and Modalities.

The proposed extension of definition for interactivity follows from the multimodal view of instruction and recognition of the cognitive processes associated with those modalities. Most past efforts to define media selection techniques have focused on the matching of media attributes, especially sensory stimuli that can be presented by a media, to those required by learning objectives. We maintain that there is ample research (Clark, 1994; Kozma, 1994; Mayer, 1996) to indicate that understanding the effects of media should also focus on how the learner interacts with the media on the basis of learner cognitive processes, prior knowledge, and other learner characteristics. Thus IMI effectiveness is not only a function of the learning task but the learner and the interaction supported by the methods designed into the media. Learners define learning goals and pursue them within the context of the support and content provided by the learning system. This is especially important to multimedia and hypermedia systems where learner control is allowed to any degree and for nonlinear learning that is inherent in much of hypermedia. Thus, in the proposed definition of IMI the instruction is learner-centered as opposed to media-centered. This will be amplified in the section to follow discussing what the relevant multimedia questions are for learning and instruction.

We are also defining media within the context of the associated methods possible for the media. Media presentation modes such as video, animations, and interactive courseware with high visual content cannot be separated from the instructional methods that are used with the media types any more than the learner's role in learning can be removed from consideration. For example, it is possible to use multimedia such as interactive courseware in an individual learning situation where the learner has no contact with an instructor or other students, in a classroom with an instructor at a "power podium," and in collaborative group learning where the students may even be separated by time and distance. The latter may be especially relevant as we move training out of the classroom to the work place. The same media can accommodate different methods and different media can be used to support the same instructional methods.

Digital Media Technology

We are defining interactive multimedia to include any learning situation where multiple technologies for providing content are used in a sensory mix either simultaneously or in sequence. We include both analog and digital media, but are focusing on digital media; including hypermedia and the new technologies emerging now such as virtual reality and 3D graphics. But we also include videoteletraining (VTT) and conferencing (VTC) when it is used with multiple media and methods to allow interactive learning by the student and recognize that VTT and VTC technology will probably someday be digital too. We are borrowing some ideas from Nicholas Negroponte, director of the MIT Media Laboratory, author of the book Being digital (1995), and a columnist on the philosophy and future of the Internet in Wired magazine, to provide a framework for how we see the relationship of digital multimedia to the trade-offs to be made in the future.

Negroponte describes bits (binary digits) as the DNA of information. According to Negroponte the shift from atoms; that is, the analog, physical representation of something (like a book), to bits is irrevocable, exponential, and changes living, work, play, and learning styles. When media are bits (digital) there are two fundamental results. First, multiple media can be commingled as bits allowing all of the information about the characteristics of each to be mixed with the other media. Second, new types of bits describing the media data further can be discovered such as the relationship of each to the others, and indications of time, locations, and motion. Any one of these bits or groups of bits can easily be changed. Any element can be reused and repurposed as well. These two aspects of digital multimedia change the media landscape thoroughly. When we consider the distribution of multimedia across space there is a new horizon on that landscape.

That is, it is possible to distribute the intelligence of the digital multimedia at both ends, client and server (or even multiple clients and servers). This contrasts, for example, with analog television of today where all of the intelligence is at the "server" and we merely select channels of that preset analog information at the client end. With digital multimedia, computers at the client end can be used to filter, sort, prioritize, manage, and perform other functions for the user including formation of the learning environment to suit the learner.

IMI Definition for IMITT

Our definition for IMI takes these aspects of learning and media technology into account. As defined by Reeves (1992) interactive multimedia is a database of multiple media representations of a content domain that becomes real in meeting learning goals only by the degree that it supports learner interaction. That database is not IMI until the interaction occurs. The interaction consists not only of the behavioral responses to cues but the cognitive processes that occur in interacting with the multimodal nature of the instruction. Those interactions will need to be supported, to varying degrees and types, depending on the learners' goals and characteristics. Learners have specific characteristics, including individual differences, that define the interaction. An implication of this definition is that the learners processing of the multimodal learning environment, including any relevant individual differences, must be accounted for in the expected interaction. These differences include aptitudes, knowledge, attitudes and motivation.

In our definition of IMI we include all forms of multimodal learning, for the sake of being able to compare different ways, delivery media and presentation modes, to present the same information in the same modalities when it is appropriate. However, IMITT will focus on digital multimedia systems in comparison with each other and with analog (including paper-based) and combinations of analog and digital multimedia.

WHAT QUESTIONS ABOUT MULTIMEDIA LEARNING ARE IMPORTANT?

It is important, in reaching our goals for the multimedia trade-offs decision tool, that we frame our questions regarding multimedia learning in the right context. Mayer (1996) has recently posed the general question, "Multimedia learning: are we asking the right questions?" Mayer's thesis, based on his research and that of others, is that it is an unproductive question to ask whether one medium is more effective than another. There is ample research (Clark, 1994; Kozma, 1994; Mayer, 1996) to indicate that understanding the effects of media should: 1) focus on how the learner interacts with media and 2) take into account different ways learners process media forms and mixes of them. These researchers and others who have reviewed work that has tried to answer that question experimentally have not been able to find any consistent effects to say that one medium is better than another. Researchers in this field generally agree that the questions need to be reframed. Kozma (1994), for example, argues that the research should focus on "media and the methods that employ them, as they interact with the cognitive and social processes by which knowledge is constructed (p.7)". Kozma goes on to say, "it is time to shift the focus of our research from media as conveyors of methods to media and methods as facilitators of knowledge-construction and meaning making on the part of learners." We agree and believe that this is the proper way to ask questions of interest in defining a pedagogical basis for multimedia decision making tools. These are important issues because they provide a basis for design of multimedia and use of digital multimedia mixes. Each of these, in turn, has trade-offs in costs, logistics, and learning effectiveness.

A THEORETICAL FRAMEWORK: DUAL CODING THEORY

We offer a theoretical framework for organizing research and its implications for multimedia learning and associated trade-offs. It is incorporated into a specification for analysis of multimedia learning effectiveness; Functional Requirement Area 5.0. Figure 1 represents the core of the theory framework. On the left side of the figure is seen the media and methods of the multimodal presentation. The framework is learner-centered in that the primary concern is the interaction of the media and methods with the learner. We will be concerned with the sensory and cognitive processes of the learner, the learner's characteristics that may influence those processes, and the learner's abilities, or lack of, to guide and regulate learning from multimedia. This learner-centered approach considers the learner to actively interact with the IMI, to generate or construct representations of the IMI content, and to associate new content with prior knowledge and representations. While we take a learner-centered approach the matters of instructional design and roles of instructors are not to be slighted. Support to the learner will be required along several dimensions at times.

A primary source for the model of IMI learning represented in Figure 1 is drawn from a theory developed by Allan Paivio (1990, 1991). Paivio presented his theory as a set of assumptions and hypotheses regarding how people represent the world around them. He took into account the structural and functional properties of the media representational systems and discussed examples of empirical implications. He also attempted to operationalize the ideas he presented. The theory is based on the general view that our cognition includes symbolic processing systems to represent environmental information. Further, these symbolic processing systems are specialized to deal with the environment in a functional and adaptive manner. The representational systems incorporate perceptual, affective, and content knowledge.

Paivio suggests that human cognition is unique in that it has evolved specialized capabilities for dealing simultaneously with both language and nonverbal objects and events. In addition, Paivio says that the linguistic processing system not only works directly with the verbal environment but, at the same time, serves a symbolic function with respect to the nonverbal environment.

This has lead Paivio to postulate a dual coding theory of cognition and the mental representations of external objects and events. Specifically, as shown in Figure 1, there are hypothesized to be two classes of phenomena processed by two separate cognitive subsystems. One subsystem is specialized for processing and representing language and the other is specialized for nonverbal occurrences. Several other assumptions and hypotheses were offered by Paivio that are worth noting here. First, he also calls the nonverbal symbolic subsystem the imagery system because part of it functions to analyze scenes in the environment and generate mental images of them. Second, both subsystems encompass other sensory modalities besides visual. The verbal subsystem accounts for both visual and aural language occurrences. The nonverbal subsystem processes visual, aural, tactile, taste, and olfactory environmental elements. Third, there is a distinction made between these symbolic subsystems and the sensorimotor modes of the five senses. The two symbolic subsystems are to be considered to retain, in the symbolic representations, the properties of the sensory modalities and consist of a network of these representations of different modalities.

MULTIMEDIA TECHNOLOGY ASSESSMENT

As specified in Functional Requirement Area 7.0, IMITT will provide the user with decision aids to make trade-offs about the technology that meets both the learning effectiveness goals and the training requirements. The technology assessment trade-offs the users makes will have a direct impact on the specification of

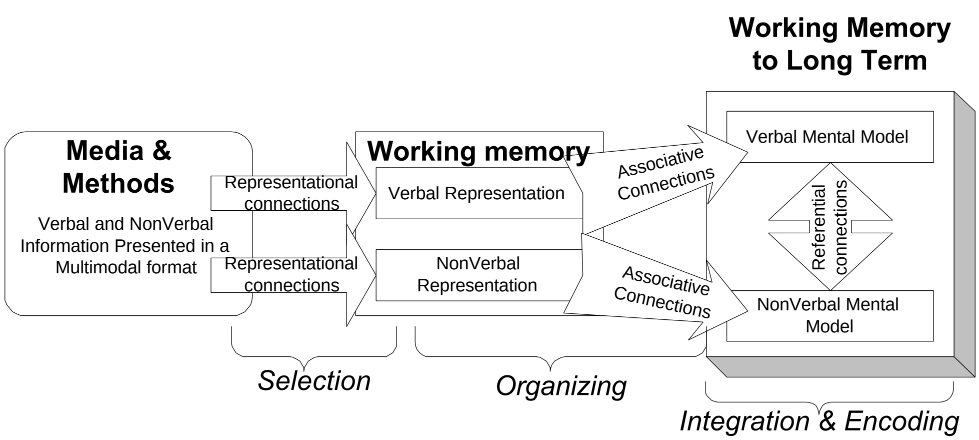

Figure 1. A dual coding theory of multimodal learning.

multimedia development and delivery system alternatives; infrastructure, logistical support and personnel requirements; and the costs/benefits analysis.

An IMI Technology Assessment Database, to be kept current and reflect the state-of-the-art, will be developed to allow users to assess IMI technology and products. Intelligent agents will be used to help ensure that up-to-date information is acquired from other technology and product databases on the World Wide Web or other Internet sources. The user will have the capability to copy and paste portions of the database, query responses, and trade-off data to a shared work space that can be transferred to another application such as a word processor or spreadsheet program.

The IMI Technology Assessment Database will be integrated with the Navy Office off Training Technology SPIDER and accessed through the World Wide Web. The database will include, but not be limited to:

- Information on multimedia technology state of the art and trends.
- Guidelines on interactive multimedia training applications based on current theory, research, and case histories.
- Information on development and delivery platforms for multimedia with third party comparison tests and assessments.
- References to other assessment organizations and results of their work.
- Cost data for development, operation and maintenance of interactive multimedia.
- Logistics and infrastructure data

MULTIMEDIA DEVELOPMENT

As specified in Functional Requirement Area 6.0, IMITT will provide decision aids to the user to assist in determining the scope of the IMI development effort and estimating the costs. Critical factors to consider include the mix of methods and media, the complexity (i.e., levels of interactive courseware and graphics), the estimated hours of instruction, the estimated number of labor hours per hour of instruction, the personnel resources available, the use of standardized style guidelines, the testing requirements, and the reusability of multimedia. The guidance provided in MIL-HDBK-1379-2, Instructional Systems Development/Systems Approach to Training and Education, and MIL-STD-1379-3, Development of Interactive Multimedia Instruction (IMI), will serve as the basis for designing the IMITT decision aids to determine the scope and estimated costs of the IMI development effort.

The identification of reusable multimedia objects and materials is an important aspect of estimating multimedia development costs, especially within DOD. The key to leveraging reusability is to catalog multimedia objects sufficiently to identify and view the object for applicability to the target training program. The following capabilities will be included in IMITT to support reusability analyses:

1. Allow the user to build specific multimedia catalogs that define media types, formats, current use, accessibility, and location, property rights, and other multimedia element characteristics pertinent to reusability.
2. Allow the user to access system wide, existing multimedia catalogs to identify, view, and possibly acquire the multimedia element.
3. Assist the user in making trade-offs about the reusability of multimedia elements in terms of repurposing, portability, fit to learning objectives, and multimodal learning effectiveness.
4. Assist the user in determining the impact of reusability on development time and costs.

The IMITT functions to analyze the reusability of existing multimedia objects and materials will be integrated and accessible through Defense Instructional Technology Information System, managed by the Defense Manpower Data Center on the World Wide Web. Periodic checks of the currency of the system catalog links and points of contact will be made through Internet intelligent agents.

INFRASTRUCTURE, LOGISTICAL SUPPORT, AND PERSONNEL REQUIREMENTS

As specified in Functional Requirement Area 9.0, IMITT will support the user in assessing the impact IMI technology will have on systems, procedures, and activities that are both internal and external to the organization. The analysis of trade-offs will be a function of the IMI development and delivery system alternatives under consideration. The trade-off factors will be translated into cost factors, as appropriate, to determine if there is any impact in investment cost estimates or changes in recurring life cycle cost estimates and/or base operating support cost estimates.

IMITT will provide editable templates to coach the user through an analysis of trade-offs in infrastructure requirements, logistical support requirements, and personnel requirements. Infrastructure trade-offs are defined as changes in facility requirements and options for communications and networking. Logistical support trade-offs are defined as changes in classroom scheduling and the impact of technology in managing the training materials inventory. Personnel trade-offs are defined as changes in instructor duties and annual instructor costs, the impact of technology on systems administration and training support functions, and requirements to train user/support personnel to operate and maintain the technology.

COSTS/BENEFITS ANALYSIS

As specified in Functional Requirement Area 10.0, the costs/benefits analysis component of IMITT will follow the economic analysis guidelines developed by DOD. The software will include a life cycle cost model (LCCM) to aggregate and display the cost estimates for initial acquisition and implementation of the multimedia learning technology and the annual life cycle management costs for operating and maintaining the technology. The LCCM will be designed to highlight the relationships between cost elements and allow the impact of changes in cost elements to be evaluated.

The objectives and desired benefits/outcomes the user defines for the multimedia trade-off analysis will determine the level of detail required in the cost/benefits analysis and the report/output requirements. Functions for guiding a user through defining the problem and setting baseline parameters for comparisons are included in Functional Requirements Areas 3.0 and 4.0. Even though a typical costs/benefits analysis component will be included, the real value of IMITT lies in the trade-off analyses performed in Functional Requirement Areas 5.0, 6.0, 7.0, 8.0, and 9.0 where factors such as cost, risk, impact, and benefits are integrated into the process of making decisions about IMI alternatives to meet the training requirements.

CONCLUSIONS

Major economic drivers are pushing the trend to use technology in instruction; specifically IMI, both in traditional schoolhouse classrooms and virtual classrooms across space and time, and in exporting training to the workplace or home. These economically driven movements are all expected to be accomplished by technology infusion, using technologies that are based, at least in part, on IMI.

This is not only a military problem. The commercial world, educational communities, and nations around the globe are now contending with the same dilemma. How can objectives be achieved with less money and how can technology be used to accomplish this? The 27 nation member (including the United States) Organization for Economic Cooperation and Development (OECD) recently cited the difficult issues facing adult learning programs affected by the use of modern technologies of computers, communications and video (OECD Proceedings, 1996). OECD stated that: (1) technologies that are relied upon should be affordable, robust, and not subject to discontinuous change that results in failures of the instructional program, (2) key areas that must receive attention are investment in staff and program development, and (3) decision makers at all levels need better evaluative tools, particularly on technology and costs, if they are to guide their own strategies for using technology to improve adult learning. OECD also stated that controlling costs must remain connected to the objectives of access and outcomes so that decisions are not made on the basis of affordability alone.

Related to all of the diverse economic drivers is the rapidly changing nature of IMI technologies and the means to carry digital multimedia in distributed modes. There are so many new directions in technology and emerging products that it is difficult for any one person to claim expertise when making decisions about application or to be able to go to a single source to evaluate technology capabilities and costs.

The trade-off factors--such as personnel requirements and training, facilities and communications preparation, logistics support, operations and maintenance, risks--and the techniques for making such trade-offs are not obvious to the typical educator or training practitioner. The costs and benefits may also not be obvious. To add new technology to otherwise unchanged programs is likely to drive costs up. As cited by OECD, to control costs it is necessary to treat cost controls as part of the overall challenge of providing accessibility and achieving desired outcomes. To control costs it may be necessary to: (1) shift to learning that is more capital intensive than labor intensive (salaries tend to go up faster than technology costs), (2) share technology resources, (3) provide integrated access in the infrastructure, (4) reduce attrition, (5) reduce the time required to complete the instruction, (6) lower capital and operating costs by moving learning to student work sites, reduce the costs of the learner and those faced by the learner, and (8) use other means to change the program made possible by technology.

For large organizations--like the military, educational communities, commercial enterprises, and nation members of the OECD-there is a danger in making decisions about technology infusion without systematically balancing the factors of access, outcomes, and costs on the basis of the best current information available and with recognition about what is not known when such decisions are made. Final decisions should be based on a balanced viewpoint that includes policy makers and funding sponsors, the training practitioners responsible for training development and operations, and the learners who will receive the training in schools and the workplace.

We conclude that the economic drivers, not only for military training but other communities responsible for adult learning, place a difficult and significant burden on training practitioners and policy makers. They are faced with the dilemma of how to use IMI and related technology, while balancing factors of cost, benefits, logistics support, and infrastructure requirements, to achieve the desired outcomes. We believe that IMITT will offer the support needed to make training and cost effectiveness decisions about implementing IMI.

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