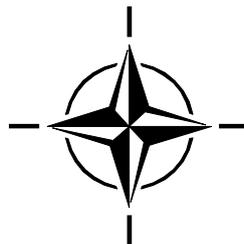**RTO TECHNICAL REPORT**   **TR-HFM-129**

Advanced Authoring Technologies, Capabilities and Opportunities

(Technologies avancées d'authoring,
possibilités et opportunités)

Final Report of Task Group HFM-129.

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Final Report of Task Group HFM-129.

The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT   Applied Vehicle Technology Panel
- HFM   Human Factors and Medicine Panel
- IST   Information Systems Technology Panel
- NMSG   NATO Modelling and Simulation Group
- SAS   System Analysis and Studies Panel
- SCI   Systems Concepts and Integration Panel
- SET   Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

Table of Contents

List of Figures/Tables

Foreword

The Human Factors and Medicine (HFM) Research Technology Organisation (RTO) Task Group (RTG) 129 began in 2004 as Exploratory Team (ET) 046. The HFM Panel (HFM) approved its Technical Activity Proposal (TAP) and the Terms Of Reference (TOR) at the Executive Session of the Research Technology Board in March 2006. HFM-129 held four meetings. The TAP and the TOR are given in Annex A and B, respectively. Annex C lists all the papers, presentations, and compact disks that resulted from work done in HFM-129. Annex D lists the principal activities of Task Group HFM-129.

HFM-129 Participants

HFM-129 participants were from the following countries and commands:

- Bulgaria (BUL)
- Canada (CAN)
- Czech Republic (CZE)
- Finland (FIN)
- Germany (DEU)
- Italy (ITA)

- Netherlands (NLD)
- Norway (NOR)
- Supreme Allied Command Transformation (SACT)
- United Kingdom (GBR)
- United States (USA)

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Advanced Authoring Technologies, Capabilities and Opportunities
(RTO-TR-HFM-129)

Executive Summary

Today's volatile operating environments make it increasingly important for learning environments (e.g., computer-assisted instruction, interactive multi-media instruction, Modeling and Simulation (M&S) for mission rehearsal and training, and simulation-based training for equipment operation, maintenance, and deployment) to adapt quickly to rapidly changing and unexpected operational requirements. Human Factors and Medicine (HFM)-129 was tasked to assess the use of software technologies and opportunities in "authoring" – designing, developing, and maintaining computer-mediated learning environments rapidly, accurately, and efficiently while sustaining – if not enhancing – their relevance and quality.

As used in this report, authoring is a generic term primarily covering three applications:

1) **Authoring languages:** Notation systems for capturing and describing the design and functional characteristics of a learning environment in a way that computer systems can interpret correctly and comprehensively.

2) **Authoring systems:** Suites of functional capabilities intended to assist instructional designers in implementing some or all components of instruction system design (i.e., analysis, design, production, implementation/delivery, and evaluation).

3) **Authoring tools:** Modular components of an authoring language and/or an authoring system.

Authoring has been a concern of computer-mediated instruction since its inception in the 1950s. It is intended to make more efficient (faster, more effective, and less expensive) the development of learning environments by subject matter specialists who have a limited background or training in computer technology. Over time, authoring capabilities have been increasingly infused with multimedia, integrated with processes intended to track, guide, and assess learning, modularized to support tailoring to the needs of individual learners, standardized to enable interoperability and reuse, and made more accessible, flexible, and easy to use. Tradeoffs between ease of use and flexibility of use are keys in enhancing the power of authoring capabilities.

The Task Group (TG) found and discussed examples of advanced authoring capabilities in four primary areas:

1) Rapid, agile development of mission training simulations by local commands;

2) Efficient, cost-effective development of simulations for operating and maintaining equipment;

3) Semi-automated generation of instructional material from standard office applications such as word processing and projection slide tools; and

4) Peer authoring using Web 2.0 technologies.

The TG found several publications that discuss the selection of authoring capabilities and products. Twenty-six questions were developed by the TG to summarize issues raised by these publications and to act as guidelines for developers in NATO and Partner countries to use in selecting among current and emerging authoring capabilities.

Technologies avancées d'authoring, possibilités et opportunités
(RTO-TR-HFM-129)

Synthèse

A l'heure actuelle, compte tenu de la versatilité de l'environnement opérationnel il est de plus en plus important, pour l'environnement pédagogique (par exemple, l'enseignement assisté par ordinateur, l'instruction multimédia interactive, la modélisation et la simulation (M&S) pour l'entraînement ou pour la répétition de mission, et la formation basée sur la simulation pour le fonctionnement des équipements, leur maintenance et leur déploiement) de s'adapter rapidement à des exigences opérationnelles imprévues et changeantes. Le groupe de travail sur les facteurs humains et la médecine (Human Factors and Medicine – HFM)-129 a été chargé d'évaluer l'utilisation des technologies logicielles ainsi que les opportunités en matière d' « authoring », de conception, de développement, et de maintenance des environnements pédagogiques informatisés, de façon rapide, précise et efficace tout en maintenant – si ce n'est en améliorant – leur pertinence et leurs qualités.

Dans ce rapport, authoring est un terme générique couvrant principalement trois applications :

1) **Langages d'authoring :** Systèmes de notation pour la capture et la description de la conception et des caractéristiques fonctionnelles d'un environnement d'étude de telle façon que des systèmes informatisés puissent l'interpréter correctement et de manière exhaustive.

2) **Systèmes d'authoring :** Séries de capacités fonctionnelles destinées à assister les concepteurs d'enseignement pour la mise en œuvre de quelques uns ou de tous les composants de la conception d'un système d'instruction (par exemple, l'analyse, la conception, la production, l'implantation/ livraison, et l'évaluation).

3) **Outils d'authoring :** Composants modulaires d'un langage d'authoring et/ou d'un système d'authoring.

L'authoring s'est intéressé à l'enseignement assisté par ordinateur depuis sa création dans les années 50. Le but est de rendre plus efficient (plus rapide, plus efficace, et moins cher) le développement d'environnements pédagogiques par des spécialistes du sujet, qui ont des connaissances ou une formation limitées en informatique. Au fil du temps, les capacités de l'authoring ont été de plus en plus liées aux multimédias, intégrées dans des processus prévus pour suivre, guider et évaluer l'enseignement, modularisées pour s'adapter aux besoins d'élèves isolés, standardisées pour permettre l'interopérabilité et la réutilisation, et rendues plus accessibles, plus flexibles, et faciles d'utilisation. Les compromis entre la facilité d'utilisation et la flexibilité sont les clés de l'amélioration des possibilités de l'authoring.

Le groupe de travail (TG) a trouvé et discuté d'exemples de capacités avancées d'authoring dans quatre domaines principaux :

1) Développement rapide, et souple de simulations d'entraînement de mission par les commandements locaux ;

2) Développement de simulations efficaces et rentables pour le fonctionnement et la maintenance des équipements ;

3) Génération semi-automatisée de matériels d'instruction provenant d'applications de matériels de bureau standards comme les outils de traitement de texte et de projection de diapositives ; et

4) Authoring par les pairs en utilisant les technologies Web 2.0.

Le TG a trouvé plusieurs publications qui traitent de la sélection des capacités et des produits d'authoring. Trente six questions ont été développées par le TG pour résumer les problèmes soulevés par ces publications et pour en faire des directives à l'intention des développeurs de l'OTAN et des nations partenaires afin qu'elles les utilisent dans leur choix d'authoring actuels et émergents.

Chapter 1 – BACKGROUND

NATO Task Groups (TGs) are established by Technical Panels operating under the NATO Research and Technology Organisation (RTO) and facilitated by the NATO Research and Technology Agency (RTA). The NATO RTO promotes and conducts cooperative scientific research and exchange of technical information among 26 NATO nations and 38 NATO partners. TGs are established by Technical Panels and charged to perform specific research activities within a specific amount of time.

TG Human Factors and Medicine (HFM)-129, "Advanced Authoring Technologies, Capabilities, and Opportunities," was established in 2005 by the RTO's HFM Panel (HFMP). The HFMP's mission is to provide the Science and Technology (S&T) base for optimizing health, human protection, well-being, and performance of humans in operational environments. This mission involves understanding and ensuring the physical, physiological, psychological, and cognitive compatibility of military personnel. It is accomplished by exchange of information, collaborative experiments, and shared field trials. The principal activities of Task Group HFM-129 are provided in Annex D.

Chapter 2 – INTRODUCTION

Today's volatile operating environments make increasingly important the ability of computer-mediated training, decision aiding, performance support, mission rehearsal, training Modeling and Simulation (M&S), and related capabilities, which may be generically described as "learning environments," to adapt quickly to rapidly changing and unexpected operational requirements. HFM-129 was tasked to assess the capabilities and use of software technologies and opportunities for "authoring" – designing, developing, and maintaining computer-mediated learning environments rapidly, easily, and effectively. An important consideration was to minimize the costs and other resources required to design, develop, and maintain these environments while sustaining, if not enhancing, their relevance and quality.

Task Group HFM-129 identified advanced technologies for authoring, demonstrated how these technologies can provide NATO forces the learning environments needed to meet today's operating requirements, and developed guidelines (Chapter 7) for choosing among them. By increasing the agility, relevance, and accessibility of these environments, the application of advanced authoring opportunities and capabilities can similarly enhance the operational capabilities and performance of NATO units.

Chapter 3 – SOME DEFINITIONS

Authoring languages, as used in this report, are technical notation systems for capturing and describing the design and functional characteristics of a learning environment so that computer systems can interpret these characteristics correctly and comprehensively. Authoring languages are a special instance of higher level programming languages. They are often intended, with greater and lesser success, to allow individuals who are not computer specialists to prepare materials for computer presentation. While authoring languages provide easy, effective use by classroom instructors, many instructors also use more generic commercial products such as Dreamweaver, Flash, and PowerPoint as authoring capabilities to create computer-based materials for their students.

Authoring tools are made available either as modular components of an authoring language or system or are provided for use in a stand-alone mode.

An **authoring system** is a suite of functional capabilities intended to assist instructional designers in implementing all the components of instruction system design – that is, analysis (to identify instructional objectives), design (to achieve instructional objectives efficiently and effectively), production (to accurately render content and design in operational software), implementation/delivery (to establish computer-mediated learning environments), and evaluation (to ensure the effectiveness, efficiency, and relevance of the learning environment). Most authoring capabilities concentrate on design and/or production of materials for implementation.

Authoring capabilities is a generic term used in this report to cover all three of these applications.

Chapter 4 – BRIEF HISTORY OF AUTHORING

As books by Galanter [1] and Coulson [2] attest, computer technology has been used to create learning environments since the 1950s. Sufficient empirical data on the effectiveness of these environments had been amassed by the early 1970s to indicate their considerable promise and value for education, training, and performance aiding (e.g., [3], [4], [5], [6], [7]). However, two significant obstacles to widespread implementation and adoption of these environments were found:

- The cost of computer technology itself; and

- The cost of preparing ("authoring") learning materials for computer control and delivery.

Moore's Law (e.g., [8]) appears to be removing the first of these problems. It suggests that the number of electronic devices (e.g., transistors) on chips is doubling about every 18 months. This pace of development seems likely to continue. Gorbis and Pescovitz [9] found that about 70% of Institute for Electrical and Electronic Engineers (IEEE) Fellows expect Moore's Law to continue holding for at least 10 more years. About 35% of them expect it to continue beyond that, up to 20 years.

The second obstacle remains. Anticipating every possible instructional interaction and every possible state of every possible learner and then incorporating all these possibilities into computer programs that organize and manage them are still expensive and time-consuming. One way around this problem is simply to ignore it and prepare page-turning instruction that allows learners to progress through material by successively typing a "next" key. Because computer-mediated instruction can deliver education and training to large numbers of learners at minor incremental costs, there are instances in which this approach may be better than residential, classroom instruction. However, it has been found to be less than optimally successful, and it fails to employ the capabilities of our current and rapidly developing computer technology and our abilities to apply it [10].

Another way to solve the problem relies on what in the 1970s was called Intelligent Computer Assisted Instruction (ICAI) and is now typically referred to as Intelligent Tutoring Systems (ITS). This approach was partially motivated by developments in artificial intelligence but more particularly by the promise of reducing or even eliminating authoring costs by enabling the computers to generate and assemble in a near conversational manner the instructional interactions of one-on-one tutoring, on-demand and in real time.

The key to this approach was envisioned by Uttal [11] and Carbonell [12] as imbuing computers with the conversational, mixed-initiative, instructional dialogue practiced by human tutors. Work in this area has continued from the late 1960s to the present (e.g., [13], [14], [15], [16]). It is a key goal of current, influential efforts such as the Advanced Distributed Learning (ADL) initiative [17] and the Defense Advanced Research Projects Agency's (DARPA) Education Dominance program. However, despite notable progress, the goal of generating instructional, tutorial dialogues on-demand and in real time remains elusive.

We are left, then, with authoring systems, languages, and tools in the hands of human developers. Like computer-assisted instruction itself, authoring capabilities have been present almost since the beginning of computer technology. The 1950s System Training Program was used to prepare technicians to operate the Semi-Automated Ground Environment (SAGE), which tracked aircraft flying over the North Pole into North American airspace. It included a variety of computer programs to help design and develop training exercises [18]. The many developers of computer-assisted instruction who, in the late 1950s and through most of the 1960s, were programming in assembler language and disdained the use of higher-order languages, including authoring languages, developed libraries of sub-routines that were, in effect, authoring tools used to speed up

and simplify the authoring process [19]. Because programmers of all sorts were expensive, few in number, and seldom aware of instructional design techniques and practices, the computer languages, tools, and systems specifically designed for use by instructional technologists in authoring materials increasingly began to appear.

4.1   AUTHORING LANGUAGES, TOOLS, AND SYSTEMS

The motivation behind the development of authoring languages, then, was to enable classroom instructors, instruction designers, and other specialists in instruction to do what computer programmers were doing but without requiring an extensive knowledge of computer programming or operations. Early, widely used examples of full-purpose authoring languages were COURSEWRITER, developed for the IBM 1500 Computer-Assisted Instruction System [20], and TUTOR, developed for the University of Illinois Programmed Logic for Automated Teaching Operations (PLATO) [21].

COURSEWRITER was a macro-oriented language that required designers to fill in the blanks of templates for macros that were then expanded into computer code. It was designed to allow elementary and high school classroom teachers to prepare computer-assisted instruction on the then state-of-the-art IBM 1500 system. Using it, they were expected to develop materials using random access to audio (stored on analog tapes), audio message recording, random access to photographs (stored on film strips), text displayed on cathode-ray tube displays, light pens, and keyboard input. As it turned out, mid-level programmers had to be hired to do this work.

TUTOR was closer to a typical higher order computer programming language than COURSEWRITER. It was, again, intended to help classroom instructors (but generally at the college and university level) create materials for delivery on the University of Illinois PLATO computer system. A prominent feature of that system was its plasma panel, which presented digitized graphics (including some primitive animation) to students, along with instructional text during the system's "teaching operations".

Both of these authoring languages assumed an instructional approach based on a combination of Keller's [22] Personalized System of Instruction (PSI) and Crowder's [23] intrinsic programming. These approaches are characteristic of much of the computer-assisted instruction designed and presented today and, more to the point, are characteristic of the approaches many developers assume in designing authoring languages and tools.

With PSI, Keller articulated the common instructional approach of dividing instructional programs into units, usually presented in a linear sequence, and then requiring students to demonstrate mastery of a unit before allowing them to proceed to the next unit. Pre-testing before entering a unit determines if a learner needs to enter it at all, and post-testing determines if the learner has mastered the material in the unit after passing through it.

A comprehensive review of PSI effectiveness by Kulik, Kulik, and Cohen [24] found that PSI programs raised final examination scores by about 0.50 standard deviations over programs using conventional (non-PSI) means of classroom instruction. They also found that PSI produced less variation in achievement, higher student ratings, and fewer course withdrawals across a variety of subject matters and course settings. However, Keller, writing in 1985 [25], was pessimistic about the future of PSI. He cited the large investment of instructor time needed to set up PSI courses and the general lack of support from administrators to compensate instructors for that time. Today, computer technology has significantly reduced the labor needed to use PSI, and it now appears to be a practicable instructional approach.

If PSI is a viable approach for managing instruction modularized into units, what approach might be used for instructional management within these units? Today, many instructional applications use "intrinsic programming" for this purpose. First described by Crowder [23] and commonly used in programmed textbooks and tutorial computer-based instruction, intrinsic programming is a practical, easily understood approach that emphasizes active responding and immediate feedback to learners. By using responses made by learners to determine their next steps, it allows for more individualization than simply allowing them to set their own pace through linear material.

The following sample instructional item, adopted from one provided by Crowder, is typical and its approach may appear familiar:

In the multiplication $3 \times 4 = 12$, the number 12 is called a _____.

    A)   Factor

    B)   Quotient

    C)   Product

    D)   Power

In this item, the system assumes that a student responding with "A" misunderstands the meaning of "Factor" and/or lacks an understanding of "Product". The student is then branched to some instructional materials intended to correct one or both of these cognitive states and returned to this item or one similar to it. The same type of remedial approach is applied to responses of "B" and "D". A student responding with "C" may be rewarded with positive feedback and sent on to whatever item continues progress toward the instructional goal(s), an action that by itself may constitute positive reinforcement.

Crowder's intrinsic programming can be found posing questions and providing individualized branching following text paragraphs, graphic displays, simulations, audio presentations, video sequences, and/or other sources of instructional content. The underlying logic remains the same: display something, elicit a response, and branch to remedial or reinforcing material depending on the response.

We can assume the application of cognitive models to be a recent innovation in technology-based instruction. However, intrinsic programming, which has been in wide use since the 1960s, requires instructional designers to anticipate all wrong responses likely to be made by learners, the misconceptions and other sources of these wrong responses, and the remedial material needed to correct them. This approach requires an underlying, albeit implicit, model of cognition and instructional progress that can be used to assess transitions from unlearned to learned states in the subject matter presented. To the extent that this model is valid, it can support individualization of pace, content, sequence, and style, and authoring because it is fairly straightforward.

In a review of 57 studies, Kulik, Cohen, and Ebeling [26] found that this type of programmed instruction, used in higher education to present a variety of subject areas, improved performance by about 0.24 standard deviations over conventional instruction. These findings (among others) suggest that the positive impact of intrinsic programming is genuine, if limited.

Today, much computer-assisted instruction uses modularization to combine Keller's and Crowder's approaches, as shown in Figure 4-1. Many authoring languages and tools, starting with COURSEWRITER and TUTOR, have been designed, with greater and lesser success, to allow instructional specialists with only rudimentary computer skills to implement this instructional approach.

From previous module → **Pre-test**

↓

Pass? → **Yes, go to next module** →

No, go to this module ↓

In the multiplication of 3 x 4 = 12,
the number 12 is called a _____.

A.   Factor   [Branch to remedial X1]
B.   Quotient   [Branch to remedial X2
C.   Product   [Reinforce, go to next]
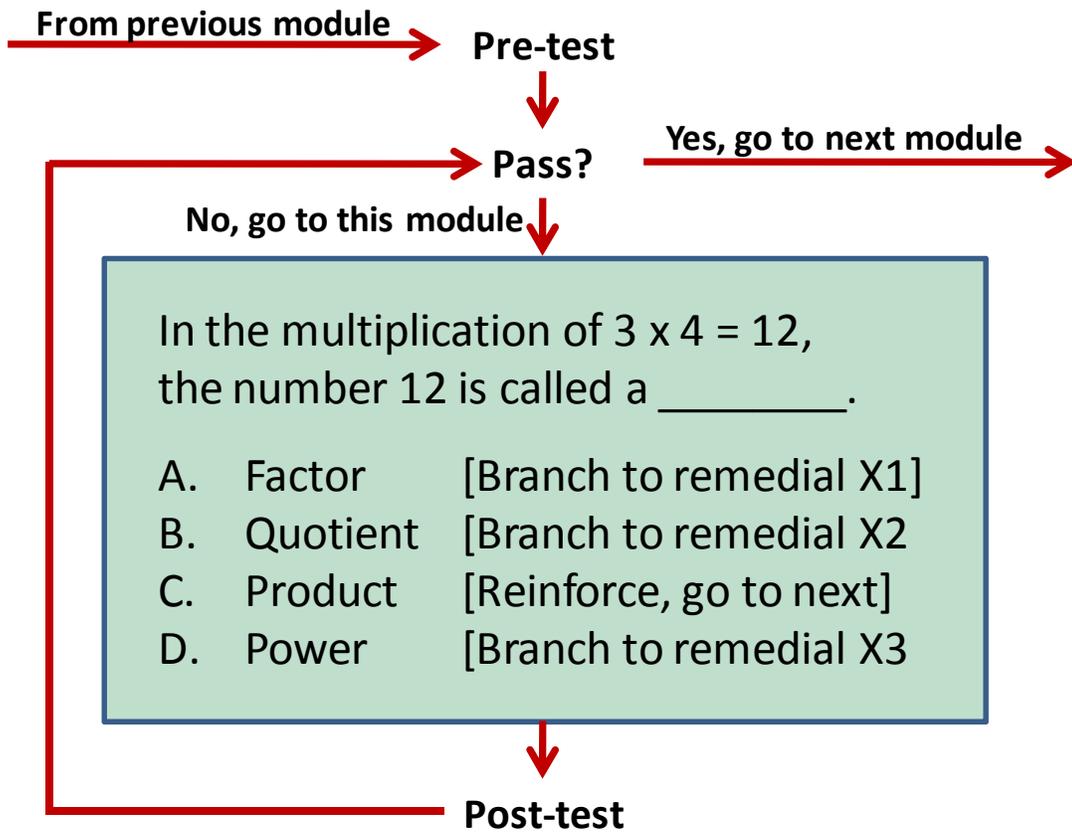D.   Power   [Branch to remedial X3

↓

Post-test

**Figure 4-1: Typical Use Case – Keller's PSI Approach
Combined with Crowder's Intrinsic Programming.**

Chapter 5 – CURRENT STATUS OF AUTHORING

The previous section notes that the development of instructional software is a costly and time-consuming process. This bottleneck is becoming more serious because current trends in learning technology, such as just-in-time and just-enough learning [27] increase the need for large amounts and many different kinds of instructional software to be created for very specific needs in very short periods of time.

Because most knowledge domains targeted for instruction are specific, instructional software needs to be developed as custom-made software by domain specialists. These specialists already possess the necessary domain knowledge and have easy access to relevant (i.e., multimedia) resources [28]. Moreover, professional instructional designers and software producers are not readily available and/or affordable. In organizations such as the military, senior domain specialists who are typically expected to teach others about their domain and to design traditional instructional materials are now being tapped to produce computer-mediated environments for instruction.

How can instructional software development by domain specialists be made more efficient (i.e., faster, less costly, easier) and more effective (i.e., improved didactical quality of the final product)? One way is to provide formal training to improve both design and production skills for creating this software. However and particularly in the military, such training is often not feasible due to lack of budget, time, and/or suitable training programs. Another way, as suggested in the previous section, is to provide authoring tools that facilitate the transition from paper-based instructional blueprints to instructional software code, making the process faster, easier, and less expensive. Such tools encapsulate and avoid the complexities of computer programming by providing intuitive interfaces, templates, and pre-structured program components.

The Task Group reviewed authoring capabilities that have been developed in six countries: Canada, Denmark, Netherlands, Norway, the United Kingdom, and the United States. No meaningful differences in authoring capabilities were found across these countries. Because authoring capabilities are intended to help developers focus on instruction techniques rather than on the computer technology required to implement them, it seems unlikely that their functional characteristics would vary substantially based on country of origin. Three NATO surveys of ADL technologies across NATO and Partner countries did not reveal any substantial differences in purpose or design [29], [30], [31]. NATO and Partner countries were found to be using similar authoring capabilities successfully.

Authoring capabilities have originated from:

- Instructional design (e.g., Authorware, Course Genie);
- Software engineering (e.g., Flash, Captivate, Office);
- Academia (e.g., SimQuest, Reusable Educational Design Environment and Engineering Methodology (REDEEM));
- Learning Content Management System (LCMS) vendors (e.g., Desire2Learn, Learn Exact);
- M&S (e.g., RAPIDS, Experimental Advanced Instructional Advisor (XAIDA), and Diagnostic Instruction and Guidance (DIAG);
- Expert systems (e.g., Demonstr8, D3 trainer, and DIAG);
- Serious gaming (e.g., Ambush!, Tactical Language and Culture Training System (TLCTS)); and
- Standardization initiatives (e.g., Reusable eLearning Object Authoring And Delivery (RELOAD)).

Vendors often claim that their authoring tools allow for the easy and rapid creation of instructional software with a high didactical quality – even when developers have little or no experience. To various degrees their claims are justified.

Over all, authoring is used to:

- Increase speed of preparation (e.g., rapid simulation/scenario generation – authoring and editing);

- Increase ease of preparation – everyone an author;

- Increase "sharability" (portability, durability, reusability, accessibility);

- Increase instructional effectiveness;

- Increase technical reliability; and

- Reduce cost of preparation.

Chapter 6 – FUTURE OF AUTHORING

Authoring capabilities are increasingly:

- **Incorporating Multimedia –** They are including interactive video, avatars, simulated entities, dynamic terrain effects, three-dimensional (3D) sound, and so forth.

- **Integrated –** They allow editing to span a larger range of technical and educational features, such as tracking and guiding learning processes, integrating a range of media with advanced simulations, and providing diagnostics.

- **Modular –** They allow selective launching or disabling of learning modules to tailor the environment for individual users.

- **Standardized –** They are enabling interoperability and reuse of individual modules and other learning content.

- **Easy to Use –** They are becoming more user friendly, especially as instructional tasks become increasingly complex.

The need for ultra-agile authoring that can be done rapidly on site by Subject Matter Experts (SMEs) continues to increase in importance. To a large extent, this need is driven by the complex, volatile demands of today's coalition, asymmetric operations. It is also driven by the Web 2.0 culture, expectations, and work habits of today's participants, who are used to constant peer-to-peer communication via capabilities such as email, texting, blogs, wikis, podcasting, Twitter, on-line games, folksonomies, YouTube, and whatever comes next.

The key to enhancing capability in these efforts, as in all authoring efforts, is to deal with the trade-off between flexibility in application and simplicity of use – a trade-off that inevitably occurs in all human-computer interactions. As suggested by Figure 6-1, it is possible to create very simple authoring languages by limiting what one can do with them – reducing flexibility, increasing simplicity. It is also possible to use authoring languages to implement quite elaborate and clever instructional designs but only at the expense of simplicity. Progress in authoring language development and design can be seen in advanced technical ideas for pushing back this trade-off and increasing flexibility while decreasing or at least maintaining simplicity of use. Achieving more flexibility or more simplicity alone is seldom enough. Advances in authoring are keyed to discovering and developing ways to do both in the same system.
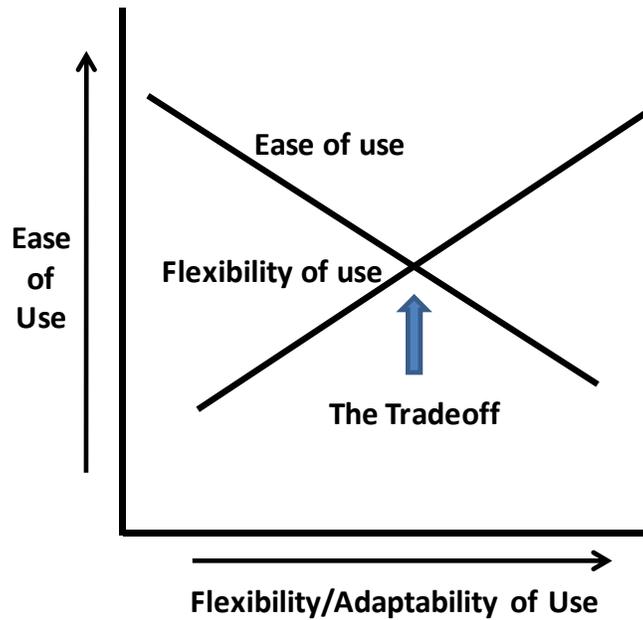
Figure 6-1: Authoring Trade-Off Between Simplicity and Flexibility.

The Task Group found examples of advanced authoring in four areas:

1) Development, modification, and maintenance of simulations in the field;

2) Development, modification, and maintenance of simulations for operating and maintaining equipment;

3) Semi-automated generation of instructional material from standard office products such as word processing documents and projection slides; and

4) Peer production arising from Web 2.0 capabilities.

A perennial characteristic of military operations is surprise. Nothing is more certain than the unexpected.

Many aspects of any operation can be anticipated, planned, and prepared for. However, with every action taken, countermeasures will be initiated, thereby precipitating a need for counter-countermeasures while the entire operation ratchets up into the usual chaos of confusion. Added to these complications are the cultural aspects of today's asymmetric operations and the need for coalition cooperation. Lessons learned in the field need to be rapidly and widely disseminated – in a matter of hours if possible.

To some extent we can prepare individuals to recognize and deal with unexpected events through training [32]. Particularly effective is training that prepares individuals by placing them in simulated environments that expose them to the unexpected events that are likely to occur in theater. Few people are likely to know and understand these events as well as those people who are actually in the field of operations. A capability that enables them to rapidly (i.e., in a matter of hours) author and/or edit simulations that incorporate newly experienced events and distribute them to others in the field will contribute significantly to attaining the resilience needed to deal with these events. With this possibility in mind, DARPA has undertaken development of authoring capabilities to "eliminate middlemen" (i.e., software programmers) and allow end users to create or edit their own simulations. As described by Kaufman and Lunceford [33]:

The overarching goal of the RealWorld program is [by using a commercial game engine] to enable non-programmers to rapidly author highly accurate, geo-specific virtual worlds and simulations. RealWorld strives to put the power of "virtual reality" directly into the hands of the people who do the work, are the experts, and often have a life-risking stake in the outcome. Its approach is to provide a robust set of easy-to-use scenario development/authoring tools that users, after very little instruction, can use to create state-of-the art 3D simulations for training, pre-mission practice, analytical evaluation of possible future events, and post-mission lessons-learned analysis. RealWorld accomplishes these ends while also driving down the cost and time lines of simulation development. Its tools can be placed in the hands of every person within an organization who has a stake in the successful execution of its missions (p. 1).

RealWorld is particularly valuable for time-critical applications where the ability to train and prepare individuals and teams in a highly accurate and realistic simulation can save lives, including those of non-combatants, and reduce mission failure risk. No matter how short the mission timeline, "practice makes perfect" applies and a simulation system that cannot be quickly adapted to local needs is of little use (p. 1).

RealWorld provides capabilities for:

- **Terrain Editing**

    - Ability to place objects from vector files (e.g., rivers and roads) in their correct locations;

    - Ability to adjust terrain elevations (e.g., properly place a road cut into a mountain side); and

    - Ability to specify ground textures (e.g., grass, sand, gravel, paving).

- **Creating Building Interiors and Exteriors**

    - Ability to import a wide range of structures from existing sources (e.g., OpenFlight and Collada files);

    - Ability to automatically texture and/or adjust texturing of objects in shape files obtained from standard sources (e.g., Laser Intensity Direction And Ranging (LiDAR) files);

    - Ability to import building interiors from Computer-Aided Design (CAD) files; and

    - Ability to generate geo-specific building interiors and exteriors by employing an easy-to-use tool.

All of these capabilities are available through simple drag and drop functions involving an object database that will continue to grow in size and diversity.

Figure 6-2 shows scenes from a simulation covering about 1 square mile and including 32 geo-typical and geo-specific buildings, 435 objects such as cars and trees, a checkpoint, and a hidden cache of weapons. It was authored in one day by an individual who was neither a software programmer nor an experienced simulationist.

Figure 6-2: Contraband Search – An Example Covering About 1 Square Mile.

RealWorld authoring also includes a 3D audio system that allows:

- Simulation participants to communicate with each other if they are within earshot range and via simulated radio (multi-channel with frequency hopping, encryption, realistic jamming vulnerabilities, and so forth) if they are not; and

- Adjustment of the type and location of sound (e.g., an explosion) as well as its intensity based on its distance.

Finally, RealWorld includes a realistic electronic warfare/threat environment to allow for integrated mission planning and rehearsal. This environment can be used in stand-alone mode, or it can be integrated with the ground environment and radio system. It enhances the immersion of simulation participants by adding functionalities beyond the visual range and imagery. Figure 6-3 shows an example of the RealWorld electronic warfare, threat, and communications environment.

Figure 6-3: The RealWorld Electronic Warfare, Threat, and Communications Environment.

A particular strength of RealWorld is its ability to link mission planning to mission rehearsal, both of which tend to be developed independently using duplicative databases. RealWorld automatically links planning data such as mission tracks, obstacles, cultural annotations, and the like to display the same data in both mission planning and mission rehearsal applications. This capability allows planners to manipulate data (i.e., author) in either database, working in either two dimensions or three dimensions, whichever provides the best view of the mission. RealWorld also provides tools to determine line of sight and path across the terrain.

It has been long noted [5] that both training and performance aiding can be generated from single underlying knowledge base, which in the case of a device could be a model representing its components and their interactions. An early instance of training and performance aiding combined in this manner was the SOPHIE system [34]. SOPHIE used a general-purpose electronic simulator, SPICE [35], equipped with a mathematical model of a regulated power supply, to create a reactive, tutorial environment for training in electronic troubleshooting.

The underlying model allowed single or multiple component faults to be introduced either by a (human) instructor or by SOPHIE itself and be propagated throughout the (simulated) power supply in a comprehensive

and vertical fashion. SOPHIE employed a semantic network of information about the power supply (one of the most sophisticated natural language processors ever built into ITS) and an articulate, expert troubleshooting capability that could not only locate and identify arbitrary faults, but also guide students in solving them.

SOPHIE responded in a realistic fashion to the actions and decisions of a student engaged in electronic troubleshooting, either for performance aiding or for training. It employed strategies that shadowed those used by the student to make inferences about the circuit based on the student's measurements and its own internal mathematical model of the circuit. SOPHIE could thereby determine which hypotheses the student or problem solver was testing, construct a model of his/her state of knowledge, and use this model to generate tailored explanations that the specific student/user would be prepared to understand. Its "articulate expertise" pioneered capabilities that are still lacking in many of today's information acquisition and retrieval systems.

However, even with its pre-supplied model, authoring for SOPHIE was expensive and time-consuming and required the services of highly experienced Lisp programmers. ReAct and DIAG are examples of serious efforts to retain SOPHIE-like "intelligent" functionalities while significantly reducing both the time and cost to produce systems of this sort [36], [37], [38]. These efforts follow a model of authoring software resources illustrated in Figure 6-4, which range from general-purpose programming languages (e.g., C++, Java), to authoring languages for interactive graphics and animations (e.g., Flash, Vcom 3D), to authoring languages for model development (e.g., ReAct and Vcom3D), to application-specific languages (e.g., Diagnostic Discrete Decision Making (D3M), DIAG, and Personal Knowledge Source (PKS)).
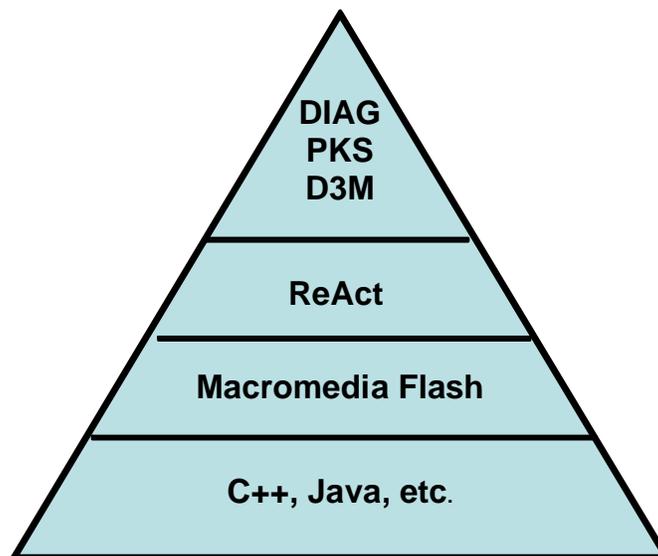
Figure 6-4: Authoring Software Hierarchy for DIAG and ReAct.

D3M, DIAG, and PKS are all based on models built by ReAct, which, in turn, requires a mid-level programmer who has knowledge of Flash. DIAG requires rudimentary knowledge of the ReAct model structure and development but not a deeper knowledge of programming. Development for operating and/or maintaining a specific or generic device, then, begins with the development of a ReAct model of the device by, perhaps a mid-level programmer, followed by DIAG development of diagnostic practice or troubleshooting by a designer who has a thorough knowledge of the device (specific or generic) but has no particular expertise in computer programming.

The requirement for the ReAct model developer is not as formidable as it may seem because ReAct expands, extends, and simplifies Flash capabilities. Among other things, it provides:

- Libraries of object prototypes for building models that include both the graphic representations and behavior of the objects. For example, an arrow for a dial object may "know" that it only rotates clockwise or counter-clockwise in two dimensions and is connected to the dial. Beyond this, ReAct objects may be physical (e.g., the above arrow), functional (e.g., schematic elements), or symbolic (e.g., a radar blip representing the intentions and capabilities of specific aircraft).

- A built-in simulation engine that responds to various inputs, including those from the user and the passage of time.

- Real-time functions for producing controlled animations that are integrated with the simulation engine.

- An object-oriented architecture that allows ReAct objects to operate independently, exchange data with each other, and combine with other objects in the fashion recommended by Boot's [39] building block solutions for authoring instructional software. Each object contains information about itself and about the objects with which it can interact, including how it must interact with them.

Even though ReAct requires some knowledge of the Flash programming that it expands, extends, and simplifies, it drastically reduces the time, effort, and cost of model development. For instance, consider the two dials shown in Figure 6-5. Both dials have identical functionality. Both objects rotate as a mouse is dragged about their centers, snap into the nearest detent when the mouse is released, and notify affected objects of their state. However, the dial on the left took 86 program statements to create and the dial on the right took one ReAct statement to create.

Figure 6-5: Rotary Dials Created with Flash (Left) and ReAct (Right).

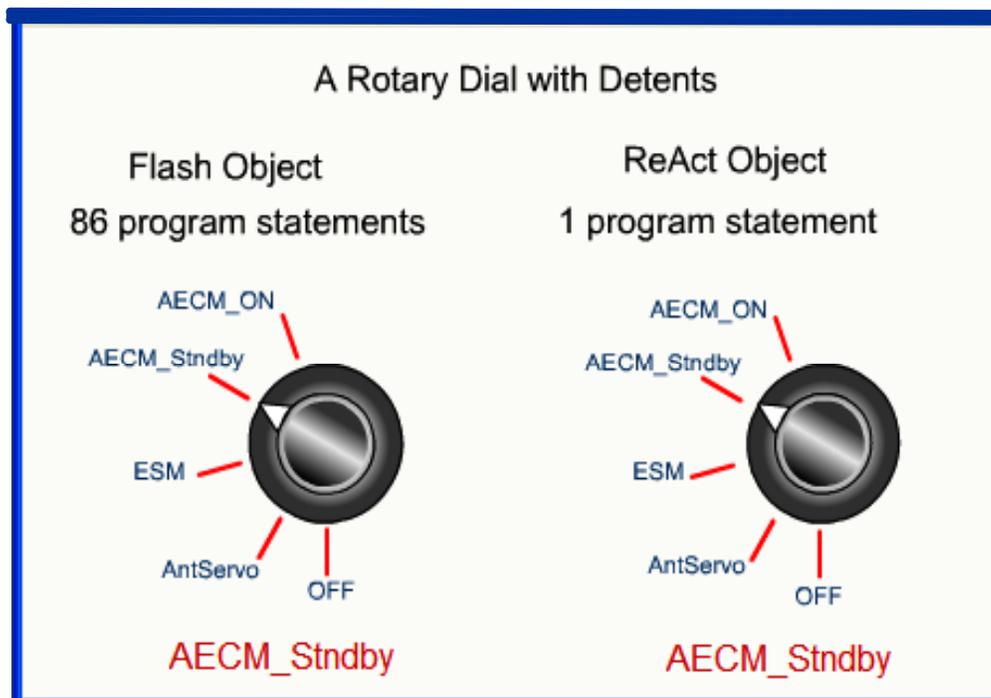DIAG was specifically developed to operate upon ReAct models in providing guided maintenance practice and diagnostic performance support. It allows users working with the models to insert and explore known faults, insert and diagnose unknown faults, get help reviewing symptoms, get help picking next system test, and get help in making inferences. The primary DIAG functions involve problem selection, recording and interpreting learner (or user) performance, providing assistance, and debriefing the learner/user following his/her problem solution. To implement training, the author simply has to hand the faults(s) to DIAG, which then invokes the ReAct simulation engine to set the indicators and test points.

DIAG is assisted in this process by fuzzy fault effect knowledge, which is based on fuzzy set theory (e.g., [40]). Here, the notion is that a particular symptom may not always occur. In the case of DIAG assessing a ReAct model with a given fault, seven possibilities for an indicator or symptom – ranging from always occurring to never occurring – are allowed. Such "fuzzy" possibilities are particularly important in learning troubleshooting for multi-component failures and intermittent component failures.

The efficiencies permitted by DIAG in authoring for equipment maintenance and operation training or performance aiding were reported by Towne [37]. The training to maintain a shipboard radar transmitter with 86 replaceable units, 17 screens, and 31 controls took 4 domain-expert person-weeks and 5 authoring person-weeks to develop. An aircraft power distribution system with 148 replaceable units, 28 screens, and 10 controls took 1 domain-expert person-week and 3 authoring person-weeks to develop.

DAIG and ReAct have been available for wider use for about 5 years. Given the ubiquity of requirements for equipment maintenance and operation and the efficiencies to be gained from use of ReAct and DIAG, it is puzzling not to find them more widely used.

One way to provide rapid, agile, inexpensive authoring is to start with standard materials such as Word documents and PowerPoint slides, with which millions of non-programmers are familiar. The computer then does the work of extracting their content and shaping it into interactive training and performance aiding materials that can be delivered by computer technology.

Several authoring tools are emerging that make this approach possible. They take word processed documents or projection slides developed by a (non-programming) producer as input and, using either hypertext markup or Graphical User Interface (GUI) procedures, help the producer structure and transform this input into a database from which computers can generate interactive, adaptive instruction or performance aiding. Using the word processor's or slide producer's font type and style conventions, assigning a hierarchical structure using different level headings to indicate ancestor and descendent sections, and assigning names to the headings, the tool produces a markup representation, which translates directly into a computer program or at least a file of material with commands for its computer delivery.

The first systems of this sort used various Hypertext Markup Language (HTML) conventions for this sort of authoring, which often handicapped portability of the resulting instructional material. As Brusilovsky [41] points out, this problem went away with the advent of Extended Markup Language (XML), which not only specifies markup conventions, but has also attracted the development of a large number of tools, editors, and parsers that conform to these conventions. Because markup alone offers considerable freedom, it also provides numerous opportunities to make subtle errors that are hard to find. In addition, although Microsoft Word can, of course, create HTML documents by itself, the code it creates cannot be easily edited by available tools, and it is difficult to make minor curriculum modifications in Word-generated HTML documents. Again, as Brusilovsky notes, a variety of checking tools have to be provided to help non-programming authors find errors and/or make modifications.

Most systems designed to assist non-programmers in developing adaptive materials from ordinary documents and slides use a GUI, with pop-up menus, drag and drop facilities, concept maps, and the like to guide users through the use of form-based tools. Many of these systems provide an input form for entering information about a concept and another form for specifying its display.

HTML and XML documents are page oriented. They expect to display a page of material (which may allow scrolling, so it is not limited to a specific page size) and wait for something to happen. It is easy to use these semi-automated systems to generate material that marches through instruction in a linear fashion in response to a learner typing a "Next" key. Simple materials of this sort can be produced quickly and inexpensively, but materials with rich content and highly adaptive information structures tend to be much more complicated and expensive to develop – to the point where it might be better to hire a developer who at least has sufficient programming skills to use an authoring or scripting language.

This is not to argue against the production of very simple materials. Large amounts of adaptive hypermedia materials can be produced from existing content in a matter of hours and made available globally on the web or whatever the global information infrastructure becomes in the future. However, it may be possible to augment these materials with more sophisticated tutoring capabilities. The capabilities developed for the REDEEM authoring environment were designed to allow classroom teachers, using a simple GUI, to adapt relatively linear, non-adaptive computer-assisted learning materials to their own presentation and delivery methods. Tests have shown that applying REDEEM to existing course content took 2–25 hours to develop an hour of newly adaptable instruction that could produce significant improvements in learning with an average effect size of 0.76 [42]. REDEEM, in combination with the semi-automated capabilities described here, might be significantly cost effective in comparison with other authoring techniques.

Gradually, the capabilities of authoring systems that allow non-programming domain specialists to produce highly effective instructional materials through guided conversations with these systems are evolving. We are not yet able to generate instructional interactions entirely by computer, but we seem to be heading toward a future in which domain knowledge will be pulled out of the global information infrastructure – on demand and in real time – to meet the specific, individual needs of a learner or problem solver on an interaction to interaction basis. In the meantime, we will have to choose between a plethora of authoring capabilities.

6.1   PEER PRODUCTION (SEE [43])

Peer production is an emerging authoring capability that complements other production resources. The rapidly increasing range and extent of human networks, made possible by computer-mediated information and communication, enable a qualitative difference in capability. It is a "more is different" type of change.

Example Scenario – *Corporal Jones had seen it happen. He was the driver of the rear vehicle when the explosion occurred. This time, there had been no casualties. He was both relieved and pleased, knowing that he had personally been involved in this success. However, this was not the case earlier when a similar roadside bomb had caused one death and several wounded. Three weeks ago, Corporal Jones had been driving just behind the lead vehicle and had seen events unfold just prior to the explosion. Immediately following that, he had spoken his recollections into his Personal Digital Assistant (PDA), taking care to describe the events prior to the explosion. He also used the PDA's camera function to take pictures of the scene. Inside the compound that night, he updated his blog and downloaded the pictures. He carefully tagged his entries, knowing that they could be used by others to learn about the incident. Over the next couple of days, many members accessed his blog and pictures. The rapid-training team in theater used Jones' account and the accounts of*

others to update the "Ambush simulation game" used to train drivers in theatre. This update was also instantly available on the network and was immediately used to train the next rotation. Jones' account was voted by his peers as "highly relevant and useful" and now appeared on the top of the wiki-based lessons-learned flash page. So, when the lead driver recognized the potential danger and took evasive action, no luck was involved. The vast network and its social production tools ensured that Jones' knowledge was quickly and effectively distributed.

6.1.1   Commons-Based Peer Production

Benkler [44] identifies "commons-based peer production" as a form of human collaboration. He defines it as decentralized information gathering that depends on large aggregations of individuals who self-identify for tasks and independently search their information environment. The fundamental advantage of commons-based peer production is that it identifies and marshals human creativity and knowledge for work on information and cultural resources.

6.1.2   Peer-to-Peer Learning

As the example scenario suggests, network capabilities, continuous learning, and effective operational agility are being interwoven within a new culture and operational paradigm. In the future, each individual may build his/her own learning, working, and operational environment. All the required information and collaborative tools and services will be integrated into a single interface – akin to today's web browser. Especially important may be the way in which knowledge and information are used and shared. The days of the senior staff as the *only* valid source of knowledge may be numbered. The emerging peer-to-peer model fits in well with today's complex and volatile battlespaces where the knowledge and intelligence of the collective are essential for victory.

While we seem to be making progress toward this model, military forces remain structured to support traditional modes of transmission, with platform instructors in front of the class. Current knowledge-sharing tools are limited. Compliance training will always be required, but the increasing influence of peer production seems inevitable. Our young students, based on their experience in the Middle East, may have much more current operational experience than their trainers. Failure to evolve from the current top-down curriculum design model to one that is more socially developmental may leave us trapped in "training for the last war".

6.1.3   Peer Production as a Human Capability Multiplier

Peer production promises to:

- Integrate continuous learning and enhance operational agility;

- Reduce the coordination costs of time, effort, resources, and people;

- Increase the pool of available skills, knowledge, and judgment that can be brought to bear on operations;

- Increase accountability, responsibility, and responsiveness; and

- Allow the organization to marshal more of its human capability/capital for productive and operational ends.

In effect, peer production can act as a human capability multiplier by allowing the people involved in administration and coordination to be redeployed into operations. It can also reduce the cost and negative effects of the replacement cycle by increasing continuity and corporate memory, thereby powering functional responsibilities with wider virtual divisions of labor.

6.1.4   Peer Production in a Military Context

Peer production in a military context can build a common picture (situation awareness), cooperatively solve problems (tactics), and maintain a progressive discourse (continual improvement and sense-making). Operational environments have far too much data, information, and knowledge for any single person to comprehend. The "work of the masses – wisdom of the crowd" will be the only way to make sense of it all. As Corporal Jones shows, information and sharing of experiences must feed back into all layers of military organizations.

In addition to knowledge sharing, peer production enhances relationships between the members of the community, which, in turn, enables the members to determine how and where they can further serve other members. It increases the organization's "social capital." Relationships, trust, and a sense of professional community are critical factors for effective connections, communication, and problem solving. They set the stage for current and future operational agility and increase the development of operational cohesion. Peer production enables a connected, decentralized network of individuals to access knowledge and resources that might otherwise be unavailable.

6.1.5   Peer Production Technologies

The capabilities of Web 2.0 have only recently emerged (e.g., [45], [46], [47]). Three of them seem particularly relevant to peer production:

1) **Wikis –** A wiki is a website with specialized software that allows its visitors to easily add, remove, and otherwise edit and change its content. This ease of interaction and operation makes a wiki an effective tool for peer production. Generally, no review takes place before modifications are accepted, and most wikis are open to the general public, without the need to register a user account. However, participants may be requested to log-in to acquire a "wiki-signature" for auto-signing edits, and private wiki servers require user authentication to edit – and sometimes even to read – pages.

2) **Blogs –** If wikis are sites of collective participation, blogs are individual productions. A blog can best be thought of as an online personal journal that can embody text, audio, and video dimensions. Blogs can be used to capture the constant chatter of the collective intelligence. Individuals can use aggregators, such as *Bloglines*, in conjunction with Really Simple Syndication (RSS) to automatically receive information that is important to them. The information contained within blogs can also be referenced, shared, and transferred into a lessons-learned wiki to improve training and operational tactics, as may have occurred with Corporal Jones' information.

3) **RSS and Aggregators –** RSS, or Really Simple Syndication, is one of the gems of Web 2.0 technologies. It allows users to "subscribe" to any piece of changing information on the net. Content can come from media sites, blogs, workgroups, and so forth as long as they have been set up for RSS. This technology allows one to keep track of large amounts of rapidly emerging information easily and concisely. It enables the mass of information likely to be produced by peer production to be managed effectively and makes peer production a practicable resource for training and performance aiding. Again, as may have occurred with Corporal Jones, RSS allowed others to be alerted without extra effort on their part.

All of these capabilities can be easily acquired and installed using open-source software.

6.1.6   Peer Production Trials: Lessons Learned

A small group of early adaptors in the Canadian Forces set out to explore wikis, blogs, and RSS. This process is continuing, even after the "launch" of a wiki and blogs. Some of the lessons learned follow:

- **Getting the Software on the Network**

  - **Lesson Learned –** Running software is imperative before one is able to sell the idea to others. Many free wikis (e.g., http://pbwiki.com/) can be used while paperwork is being processed. Use care in posting information discussions in the open arena of the Internet.

- **Convincing Others the Way of the Wiki –** Inevitably, people have a difficult time with the concept of the wiki as being able to be edited by all. Much discussion (http://en.wikipedia.org/wiki/Wiki; [48]) of that issue and those related to it has ensued. Most wikis allow for easy restoration of previous content, provide a complete history of edits (including who made the edit), and have a designated space for discussion associated with the article.

  - **Lesson Learned –** Ensure that there are no anonymous users on your wiki. Have them use their official work email address and real names. This caution eliminates vandalism and misuse.

- **Canadian Forces Wiki** – The Canadian Forces wiki was never publicized. In 6 months, membership was well over 150 users and over 100 articles. Users have been free to use the wiki for whatever purpose they deem fit. Very little support was provided, but, by all measures, the wiki is being used successfully. Most users just open an article for editing and pick up the wiki-coding by themselves. If peer production is to take up some of the authoring burden, the costs of doing so will be minimal.

  - **Lesson Learned** – Find a group that is already doing something for which a wiki could improve a person's ability to do it. Start small and let it grow organically. Do not force people to use the wiki. Do not limit access. Do not restrict reading or editing rights.

- **Canadian Forces Blogs** – Blogs were also introduced to the Canadian Forces with, again, very little advertisement. Further, less than 10% of Canadian Forces have access to these blogs. Despite these limitations, a regular group of bloggers is sharing information. Reading and commenting on others' blogs by the core group seems to be keys to building trust and increasing use of the blogs. Ultimately, the increased use of blogs will require open access and expanded scope. However, the Canadian Force is a "need-to-know" organization whereas peer production promotes a "need-to-share" culture. Policies and techniques will have to be developed before peer production can become widely implemented.

  - **Lesson Learned** – Allow users to explore how blogs can be useful to them. Encourage use by reading and commenting on others' blogs.

- **Canadian Forces' Use of RSS and Aggregators –** Canadian Forces' use of RSS and aggregators has been limited to 3 – 4 early adaptors. These technologies have been introduced at several conferences and have engendered considerable interest. The Canadian Forces have many readily identifiable groups that could easily benefit from the ability to share their "favorites." RSS and aggregators help ensure receipt of the most current information delivered anytime, anywhere. However, the Canadian Forces are not able to use aggregators within their firewall. A separate computer and network must be used. Again, policies and techniques must be developed before the promise of these capabilities can be fully realized.

  - **Lesson Learned** – With limited resources, promote the peer production technologies that will have the greatest effect on the organization and can be implemented with minimal impact on

current policies. The technology must be used by users to gain insights into its functionality and usefulness.

6.1.7   Peer Production Challenges

Peer production holds considerable promise for easing authoring costs, but it is still in the very early stages of adoption. To reach the state of sharing and learning that we saw in the Corporal Jones scenario, some challenges must be met. Dealing with a "need-to-know" organization that needs to develop the trust and access required by a "need-to-share" technology will take time. However, its value is likely to be understood and perhaps demonstrated by the new generation of people in the Canadian Forces.

A slow revolution appears to be changing our views of knowledge. We are moving away from objectivism and toward a social constructivism where reality is a collective interpretation. Critical thinking will be especially important in justifying assertions and judging the validity of data, information, and knowledge, regardless of the source. It may be at the root of peer production's success of failure. Nonetheless, the trials thus far have been encouraging.

Other developments, such as RealWorld authoring, are in accord with the authoring environment evolving from Web 2.0 capabilities in which everyone is an author, including the learners and users themselves.

Chapter 7 – GUIDELINES FOR SELECTING AUTHORING CAPABILITIES

Publications on and discussions of how to choose authoring products abound (e.g., [49], [50]). The Task Group decided early on to mention specific products as examples only and to avoid specifically recommending any for at least three reasons:

1) The product list is constantly changing.

2) The recommendation of any one or group of capabilities creates issues with those not selected or inadvertently neglected.

3) Primarily, however, recommending any specific capabilities to a general audience is impossible. The choice depends on who will use them to do what and under what constraints of cost, time, and other resources. Few one-size-fits-all authoring capabilities exist.

With these considerations in mind and after reviewing a variety of the many guidelines for selecting specific authoring capabilities and tools, the Task Group arrived at 26 summary issues. These issues are listed in Table 7-1 and discussed in the paragraphs following the table. These issues suggest matters to be considered by anyone selecting authoring capabilities for computer-mediated instruction. They are based on an early paper prepared for the Task Group by Boot and Kitchen [51].

Table 7-1: Issues to Consider in Selecting Authoring Capabilities and Tools.

What does the tool do?	Who will be developing the instruction?
What is the quality of the tool?	What does the tool cost?
How reliable is the supplier providing the tool?	How widely used is the tool?
What technical support is available?	What media does the tool support?
With what standards and specifications (if any) does the tool comply?	What instructional strategies does the tool support and how well?
What support for analysis does the tool provide?	What student progress recording does the tool support?
For what development environment(s) is the tool intended?	What developer aids does the tool provide?
What are the systems requirements for the tool?	How easy (or difficult) is the tool to set up and use?
What curriculum structuring does the tool provide?	How extensible is the tool?
What interactive formats does (e.g., questions and answers) the tool support?	What navigation controls does the tool provide?
What text options does the tool support?	What graphics options does the tool support?
What sound options does the tool support?	What learner control options does the tool support?
What natural language(s) does the tool support?	How are this tool and its products maintained?

7.1   SELECTION ISSUE #1: WHAT DOES THE TOOL DO?

Where in the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) cycle does the tool fit? As may be apparent from this report, most authoring capabilities concentrate on development – getting the material out of designers' heads and into the computer. Evaluations in the form of student assessment, test construction, and student reporting receive less, but appreciable, attention from authoring tools. Rarely, however, do these evaluations treat the design of instructional materials and help identify instructional approaches that reliably lead to instructional outcomes as Woolf and Regian [52] discuss under the heading of instructional engineering. Attention to implementation is lacking, and this inattention is unfortunate because of the extent to which blended approaches of direct technology-based instruction and classroom and human instruction are being used across NATO / Partner countries (e.g., [53]). Also, finding authoring capabilities that deal with the system issues of instructional analysis to any degree is difficult.

Most authoring capabilities are developed on the assumption that analysis and design have been completed before they are called into use, and this assumption may be sufficient for many users. However, the area of development has many varieties of tool functionalities. Some tools are designed to provide a full suite of development services, including course unit mapping (which units fit where); a full array of interaction possibilities, including a wide spectrum of multimedia possibilities; many forms of answer processing, individualization, and branching in response to student input; and so forth. Examples of these types of authoring tools are found in such "full-service" capabilities as CourseBuilder, Desire2Learn, and Authorware. Other tools focus on importing PowerPoint slides or Word documents into an instructional sequence (Rapid, Course Genie), some are only concerned with learner assessment and the construction of tests (the Assessment Design and Delivery System (ADDS) developed by the Center for Research on Evaluation, Standards, and Student Testing at the University of California at Los Angeles (UCLA)), and still others focus on the development of simulations (RealWorld, DIAG, ReAct).

Some authoring tools are designed to operate with other software, which may be other authoring tools intended for the development of instructional materials (e.g., DIAG and REDEEM) or more general-purpose software (e.g., Flash). In either case, the tools are likely to assume coordinated application of other software packages with which users are expected to have some familiarity and facility.

Finally, many authoring capabilities do many things. However, some things are more easily done than others. The predominate instructional approach planned for implementation should be identified and then used to test candidate capabilities to ensure that it is not inordinately difficult to implement using one or another of them.

7.2   SELECTION ISSUE #2: WHO WILL BE DEVELOPING THE INSTRUCTION?

A perennial observation about any development leads with the following question: Do you want the development to be done inexpensively, quickly, or well? **Pick two**.

Of course, we would like to choose all three options, but choosing just two turns out to be far more realistic. The observation can be applied to the first issue in choosing an authoring tool: Who will develop material using it? Table 7-2 illustrates, in the context of the question concerning cost, time, and quality (expanded to consider content, instructional design, and technological production), the notional consequences of various choices prior to selecting an authoring tool.

Table 7-2: Likely Consequences Arising from Choice of Developer(s).

Developers	Quality				
	Inexpensive	**Quick**	**Accurate Content**	**Good Instructional Design**	**Good Technological Production**
Training Technologist	N	N	?	Y	Y
Information Technologist	N	?	N	N	Y
Domain Specialist	?	N	Y	N	N
Local Commands	Y	?	Y	N	N
Authoring Teams	N	N	Y	Y	Y

Note for Table 7-2: *N = Probably No; Y = Probably Yes; ? = Unknown.*

Table 7-3 suggests what we can realistically hope would result from the appropriate choice of authoring tool(s). Some outcomes still remain uncertain, but the number of "probably no" judgments is down to one.

Table 7-3: Likely Consequences with Appropriate Choice of Authoring Tool(s).

Developers	Quality				
	Inexpensive	**Quick**	**Accurate Content**	**Good Instructional Design**	**Good Technological Production**
Training Technologist	?	Y	?	Y	Y
Information Technologist	N	Y	?	?	Y
Domain Specialist	?	Y	Y	?	Y
Local Commands	Y	Y	Y	?	Y
Authoring Teams	?	Y	Y	Y	Y

Note for Table 7-3: *N = Probably No; Y = Probably Yes; ? = Unknown.*

However accurate these judgments may or may not be, Tables 7-2 and 7-3 emphasize that the choice – or simply the availability – of people to do the authoring is important and should be considered up front in deciding what authoring tools to select for a development.

Questions along this line might include the following: What assumptions did the tool's developers make about its users? Is it primarily intended for use by instructional technologists, information technologists, SMEs, computer programmers, or classroom instructors? What support does it provide to these different classes of users?

An important issue is whether the tool will be used by individuals or teams. Some systems provide explicit aids for team development. Boot's [39] research addresses the issue of using authoring tools to facilitate communication between instructional designers and SMEs who are designing the materials and the software engineers who are implementing the designs in computer code. Boot's research suggests the need to consider the depth of technical quality among the people involved in design and development. He found that authoring tools could compensate somewhat for lack of expertise – but only to a limited extent.

7.3 SELECTION ISSUE #3: WHAT IS THE QUALITY OF THE TOOL?

Authoring tools cannot be held solely responsible for low-quality instructional materials any more than they can be given full credit for high-quality materials. They are, after all, tools. The choice of authoring tools should include a review of products for which they have been used in the past. Assessments of these products for technical and instructional quality and for ease of implementation are not always available from empirical tests, but they are highly desirable and should be sought.

7.4 SELECTION ISSUE #4: WHAT DOES THE TOOL COST?

Some questions about cost issues are as follows: What licensing agreements are available? What enterprise-wide licenses, if any, does the tool offer? What update and maintenance fees do the vendor charge and on what schedule? Are single-user licenses available?

7.5 SELECTION ISSUE #5: HOW RELIABLE IS THE SUPPLIER PROVIDING THE TOOL?

Some questions about the supplier are as follows: What is the size of the company? How long has it been in operation? How many authors are using the tool? What is the experience level of the company staff? What types of organizations are among its clients? What is the company's reputation for quality, service, and price? How current is this information?

7.6 SELECTION ISSUE #6: HOW WIDELY USED IS THE TOOL?

The more widely used the system, the more likely that assistance will be available and the more likely that it will be supported in the future. This issue suggests a bootstrapping problem for tool developers. They may have few users because they do not know how to provide good service, and their inadequate service prevents them from having enough users to show them how to improve it.

7.7 SELECTION ISSUE #7: WHAT TECHNICAL SUPPORT IS AVAILABLE?

A sufficient population of users will support vigorous and knowledgeable user groups that are capable of answering questions themselves and also can point out improvements needed in the authoring tool and indicate what priority these improvements deserve. In addition to active user groups, telephone assistance should also be available at all times, and the assistance should be able to reach back as far as necessary to find technicians who have the knowledge needed to solve whatever problems may arise. In addition, even though user groups can provide considerable training and other resources needed by those using the author tool, the supplier should provide relevant and accessible training for all levels of users. Finally, the technical and functional documentation should be up-to-date and of high quality.

7.8 SELECTION ISSUE #8: WHAT MEDIA DOES THE TOOL SUPPORT?

A substantial body of research has demonstrated that visual (parallel) and verbal (serial) processes operate in a cognitively additive and complementary fashion [54]. At the most concrete level, pictures and speech/text operate together to increase learning and transfer more than either can in isolation. In brief, multimedia capabilities enhance learning, and the authoring capabilities that support them will encourage better instructional practice.

Determining what media an authoring tool can display to learners and problem solvers is worthwhile. Selection of a tool should be keyed to the media that designers plan to use. Text, graphics, animation, video, audio, voice recognition, and external instrumentation (e.g., light pens, track balls, and mouse clicks), along with sensors of all sorts, are of interest in this decision.

Some questions might include the following: What graphic and animation files does the tool support (e.g., Joint Photographic Experts Group (JPEG), Graphics Interchange Format (GIF), Portable Network Graphics (PNG), and Small Web Format (SWF))? What and how does it support streaming video and streaming audio? What editing capabilities does it provide for graphics, automation, video, and audio? Does it support simple interfaces with external hardware, real-time control of external hardware, and/or overlay and synchronization of external video? As with all features, one should assess not only if these capabilities are available, but also how easy they are to use.

7.9 SELECTION ISSUE #9: WITH WHAT STANDARDS AND SPECIFICATIONS (IF ANY) DOES THE TOOL COMPLY?

Industry-wide standards and specifications are critical in today's authoring environments (e.g., [55]). They include the Sharable Content Object Reference Model (SCORM), Content Object Repository Discovery and Registration/Resolution Architecture (CORDRA), Learning Object Metadata (LOM) specifications, the Aviation Industry Computer-Based Training Committee (AICC) HTIP-based AICC/CMI Protocol (HACP), IMS Content Packaging, IMS Question and Testing Interoperability, and others. Many of the authoring capabilities reviewed by the Task Group are SCORM compliant. The exceptions tended to be capabilities developed for research purposes.

Additional standards and specifications can be expected to emerge as efforts continue to increase the standardization of practices that enlarge the market for technology-based instruction. It is important to ask with which, if any, industry standards or specifications does the tool conform. It is also important to determine which of these industry standards or specifications are certified by the standard/specification organization to

be genuinely compliant. The marketing enthusiasm of vendors may lead them to claim compliance with a popular standard or specification. Their certification of compliance should be verified.

7.10   SELECTION ISSUE #10: WHAT INSTRUCTIONAL STRATEGIES DOES THE TOOL SUPPORT AND HOW WELL?

Most technology-based instructional strategies can be broadly classified as drill practice, tutorials (as in the Keller / Crowder PSI / intrinsic programming example discussed earlier), simulations, games, and generative or "intelligent" techniques (as in the guided conversations that remain the aim of ITS development). Even the most straightforward of these strategies – drill and practice – may require randomization of presentations, dynamic pooling of items, mathematical modeling of student progress, dynamic parameter estimation, and other ways of modeling the learner as, for instance, described by Foster and Fletcher [56].

Within these strategies, what branching capabilities does the tool support? Does it support an unlimited number of menu branches – branching based on learner responses, branching based on elapsed time, and/or branching based on number of tries? Again, most instructional capabilities can be supported by most general-purpose authoring tools, but some are more easily supported than others. Selection of an authoring tool should include a consideration of the most effective and efficient strategy to achieve the targeted instructional objectives and the ease or difficulty with which it supports that strategy.

7.11   SELECTION ISSUE #11: WHAT SUPPORT FOR ANALYSIS DOES THE TOOL PROVIDE?

Does the tool provide automated data capture and storage? What statistical analyses techniques does it support? To what and in what detail does it capture and record student responses? Does it include both keyboard and click stream data input and latencies? Does it support item analyses, item characteristic curves, and analyses of simulations and simulation scenarios? If the tool does not support the analyses needed by a program of technology-based instruction, separate computer programs to provide these analyses will have to be purchased or developed.

7.12   SELECTION ISSUE #12: WHAT STUDENT PROGRESS RECORDING DOES THE TOOL SUPPORT?

Can the tool easily generate reports on individual students or students organized into groups specified by instructors and administrators according to project groups, classrooms, academic discipline, demographic data, and so forth? If it supports these groupings, what specific data can it report? Can these data be linked to instructional objectives in ways that are useful to educational analysts, administrators, and classroom teachers? What capacities for collecting, storing, and, especially, protecting individual learner data does the tool support?

7.13   SELECTION ISSUE #13: FOR WHAT DEVELOPMENT ENVIRONMENT(S) IS THE TOOL INTENDED?

Is the tool intended for use only in a stand-alone environment or does it include provisions for networked, collaborative development?

7.14 SELECTION ISSUE #14: WHAT DEVELOPER AIDS DOES THE TOOL PROVIDE?

For instance, does the tool provide spell checking, thesaurus access, a "What You See Is What You Get" (WYSIWYG) interface, drop and drag objects, and instructional content and sequence tracing? Does it provide quick-preview functions? Can it print content for learners and/or authors?

7.15 SELECTION ISSUE #15: WHAT ARE THE SYSTEM REQUIREMENTS FOR THE TOOL?

This issue is one of the most important in selecting authoring capabilities. What hardware and system software are required for authors to use the tool? What hardware and system software are required for learners and users to apply the tool's products? What are the minimum capabilities required? Beyond these minimums, what capabilities and capacities are recommended by the tool providers?

7.16 SELECTION ISSUE #16: HOW EASY (OR DIFFICULT) IS THE TOOL TO SET UP AND USE?

For what operating environment is the tool intended? Does it require learning management systems, learning content management systems, or specific instances of these to function? Does it require plug-ins and/or software capabilities that must be obtained separately?

7.17 SELECTION ISSUE #17: WHAT CURRICULUM STRUCTURING CAPABILITIES DOES THE TOOL PROVIDE?

Does it provide overall course, module, and/or topic structuring capabilities such as tree structures, storyboards, or concept maps? Does it integrate the structure with ongoing activities by designers and developers to provide advice, reminders, and/or review of development progress?

7.18 SELECTION ISSUE #18: HOW EXTENSIBLE IS THE TOOL?

What, if any, computer or scripting language(s) does the tool support or require? How and how easily can authors develop their own templates?

7.19 SELECTION ISSUE #19: WHAT INTERACTIVE FORMATS (E.G., QUESTIONS AND ANSWERS) DOES THE TOOL SUPPORT?

Does the tool support (perhaps with templates and/or content wizards) formats such as true/false, multiple choice, short answer, fill-in-the-blank, essays (graded by an instructor or by computer), matching, sequence, hot-spot, drag and drop? Does it provide a means to align displayed objects, place objects precisely, synchronize different display modalities (e.g., appearance of visual objects with accompanying audio), and hyperlink objects to other resources? Does the tool support presenting questions in random order, presenting multiple choice distracters in random order, presenting questions drawn from a pool, automatically stored student responses, turning feedback on and off, randomized feedback, timed questions, timed tests, tests that automatically select content based on learner performance, and branching based on responses?

7.20   SELECTION ISSUE #20: WHAT NAVIGATION CONTROLS DOES THE TOOL PROVIDE?

Does its standard interface include controls such as "next," "back," "exit," "view menu," "glossary," "help," and "bookmark"? Does the tool support radio buttons, pull-down menus, list boxes, scroll bars, and dialog box frames?

7.21   SELECTION ISSUE #21: WHAT TEXT OPTIONS DOES THE TOOL SUPPORT?

Does it support variable fonts, sizes, and colors, variable styles (bold, underline, italic, and so forth), variable formats (centering), importing of text, and search and replace?

7.22   SELECTION ISSUE #22: WHAT GRAPHICS OPTIONS DOES THE TOOL SUPPORT?

Does it support a variety of objects (line, box, shapes, and so forth), high-resolution color, animation options, graphic scaling and rotating, bitmapped graphics, object-oriented graphics, graphics and/or text overlay, and screen capture?

7.23   SELECTION ISSUE #23: WHAT SOUND OPTIONS DOES THE TOOL SUPPORT?

Does it support computer-generated sounds, synthesized speech, 3D audio, and digitized audio editing and play?

7.24   SELECTION ISSUE #24: WHAT LEARNER CONTROL OPTIONS DOES THE TOOL SUPPORT?

Does it support learner control of sequence, programmable learner control keys, learner restart options, learner bookmarking, learner access to dictionary or glossaries, learner access to note-taking facilities, and learner access to printing of selected information?

7.25   SELECTION ISSUE #25: WHAT NATURAL LANGUAGE(S) DOES THE TOOL SUPPORT?

What natural (i.e., human) languages and character sets does it support? This question is particularly important for NATO and Partner developers. It applies to reference and training manuals (on-line and/or off-line), to controls and statements used by the tool, and to features such as spelling and grammar checkers. Even though the learning materials will be presented in one language (e.g., English), production-support materials should also be provided in languages that are more familiar to the designers and developers of the materials.

7.26 SELECTION ISSUE #26: HOW ARE THIS TOOL AND ITS PRODUCTS MAINTAINED?

A not-uncommon problem is that instructional materials cannot not be maintained or updated after a period of time because the tools or, more frequently, the versions of the software used to develop these tools are no longer available. What solutions does the tool provider(s) offer for this problem? What version and configuration management do the tool provider(s) offer?

Chapter 8 – SUMMARY

Authoring capabilities have progressed substantially since the days of the SAGE System Training Program, COURSEWRITER, and TUTOR. These new capabilities have become increasingly agile, easy to use, wide ranging in their coverage of instructional approaches, and automated. They can now be used by many people – especially those who do not have substantial experience in computer software technology – to produce high-quality technology-based instructional materials rapidly and inexpensively. Thanks to several standardization efforts, these capabilities can generate material that is portable across many platforms, durable despite frequently introduced modifications of underlying system software, and reusable.

A significant portion of authoring capabilities will probably evolve in the direction of peer production, thanks to the rapidly growing marketplace for Web 2.0 materials. The goal of fully automated (generative and on-demand production) systems remains elusive, but progress has been made in using commercial databases, such those from CAD for equipment operation and maintenance and those from professional simulation vendors for in-theater training and mission rehearsal, to generate realistic learning environments. Finally, the body of empirical data to demonstrate the ability of authoring capabilities to reduce costs, time, and other resources in the production of education, training, and performance aiding environments is growing in quantity and quality. Evidence of cost effectiveness to inform trade-off decisions is still needed, but it, too, is being produced, albeit erratically and slowly. Nonetheless, the value of authoring capabilities seems sufficiently demonstrated by current data and user acceptance to ensure its continued development and evolution.

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Annex A – TECHNICAL ACTIVITY PROPOSAL (TAP)

TECHNICAL ACTIVITY PROPOSAL (TAP)

Activity	ET	Advanced Authoring Technologies, Capabilities, and Opportunities										TBA	
Activity Ref. Number	ET-046											08/04	
Principal Military Requirements		(1)	(2)	(3)	(4)	(6)	(7)			NU		05/05	
Military Functions		(1)	(2)	(3)	(4)	(5)	(6)	(7)	8	9	10	11	12	
Panel and Coordination		HFM						NTG			(11)		
Location and Dates		August 2004 in St. Petersburg, FL									P-I		
Publication Data		TR			4/06		75 pgs		NU				
Keywords	Training	Education		Authoring			Curriculum						
Human Systems Technology		Training Development		Learning Systems			Computer-Mediated Instruction						

I. BACKGROUND AND JUSTIFICATION (RELEVANCE TO NATO)

From 1985 through 2003, NATO has held workshops on technologies associated with military training. These workshops covered Computer-Based Instruction, Training System Design, Distributed Training, and Virtual Reality. While technologies have dramatically changed, many of the problems and issues related to training technologies – its application, acceptance, and effectiveness – are still relevant today. The restructuring of the military forces in size and composition, along with decreased funds for real exercises, has continued to focus attention on how to maintain a well-trained and flexible force. Recent changes in NATO and the European infrastructure have stimulated the Research Technology Organization (RTO) to sponsor an October 2003 symposium that focused on technologies applicable to improving military training.

Military training must prepare individuals to enter into harm's way and perform physically and mentally demanding tasks at the highest possible levels of proficiency in a time-critical manner. This requirement may be the defining characteristic of military training. With advanced technology available to any buyer, training can mean the difference between success and failure, life and death. Such training must be dynamic, allowing continual, just-in-time modification and updating – especially when it is to be distributed anytime and anywhere it is needed. Meeting this requirement requires authoring capabilities for the rapid development of training materials that are maximally responsive to changing operational requirements, adaptive to cultural differences, and readily used by military personnel. This technical tool will be especially important for preparing NATO Response Force (NRF) command personnel by computer-mediated, just-in-time training systems that will be the standard training and mission rehearsal tools of the future.

II. OBJECTIVE(S)

This Exploratory Team (ET) will focus on recommendations made at the conclusion of the October 2003 symposium in Genoa, Italy. These recommendations concern the use of technologies to develop computer-

mediated training environments quickly and effectively. This focus suggests that the ET analyze the value and opportunities provided by advanced and emerging technology-based authoring systems. The ET will use the analysis to formulate a TAP and Terms of Reference (TOR) for a Human Factors and Medicine (HFM) Task Group. One element of the TOR for the Task Group will be the scheduling of a "Cooperative Demonstration of Technology" (CDT) and/or a Specialists' Workshop as the capstone events for the work of the Task Group.

III. TOPICS TO BE COVERED

- State-of-the-art of authoring systems and **its uses in NATO** (e.g., for selection of curriculum content, selection of instructional approaches, design of instruction, efficient development of materials, efficient achievement of targeted instructional outcomes, contributions to operational effectiveness);

- Measuring the costs and effectiveness of authoring systems as these systems contribute to improved human performance;

- Guidelines (including what works) for operational application of current and advanced authoring systems;

- Use of simulation (including game technologies) in the authoring process; identifying where and what type of content it can be most effective/efficient for authoring;

- Automated and/or 'intelligent' capabilities for authoring;

- Sharable, reusable instructional objects used in authoring and examples of the cost/value of interoperability;

- Authoring of "stories" for adaptable case-based learning environments; and

- Authoring of performance aiding (as well as instructional) capabilities.

IV. DELIVERABLE AND/OR END PRODUCT

Report to the HFM Panel by the Spring 2005 meeting on the feasibility of establishing a Task Group.

V. TECHNICAL TEAM LEADER AND LEAD NATION

Dr. Dexter Fletcher, Institute for Defense Analyses (IDA) (01) 703.578.2837, fletcher@ida.org, USA.

VI. NATIONS WILLING TO PARTICIPATE

Initial membership will be invited from the program committee of the recent training symposium and from the recently completed Advanced Distributed Learning (ADL) Task Group. These nations include Belgium, Canada, the Czech Republic, France, Germany, Italy, Netherlands, the United Kingdom, and the United States.

VII. NATIONAL AND/OR NATO RESOURCES NEEDED (PHYSICAL AND NON-PHYSICAL ASSETS)

Access to representative software currently being used for authoring; access to knowledgeable, representative users of authoring systems; ability to participate in teleconferences and email to reduce the need for face-to-face meetings; and willingness to experiment with advanced authoring techniques to assess technical opportunities,

international and cultural issues, Research and Development (R&D) priorities and requirements, and NATO operational priorities and requirements.

VIII. RESEARCH AND TECHNOLOGY AGENCY (RTA) RESOURCES NEEDED (E.G., CONSULTANT FUNDING)

Three consultant trips tied to meetings at locations to be identified.

Annex B – TERMS OF REFERENCE (TOR)

I. ORIGIN

A. Background

This Task Group (TG) responds to recommendations made at the conclusion of the Human Factors and Medical Panel Symposium on Advanced Technologies for Military Training held in Genoa, Italy, in October 2003. These recommendations concern the use of technologies to develop computer-mediated training environments quickly and effectively. This Exploratory Team (ET) is to review the value and opportunities provided by advanced and still-emerging technologies for creating such environments and suggest their further development focused on NATO requirements for future training capabilities.

As reviewed in many NATO studies, the case (based on empirical data) for computer-mediated learning environments can be summarized from the literature as follows:

- Tailoring instruction (education and training) to the needs of individual students has been found to increase learning outcomes by as much as two standard deviations, which is roughly equivalent to raising the achievement of 50th percentile students to that of 98th percentile students. However, requiring one (human) instructor for every student is an economic impossibility.

- Computer technology can, in many cases, make this proven instructional capability affordable. Under any appreciable student load, it is much more cost effective to deliver instruction using technology than to provide a (human) tutor for each student. Such technology supplies much of the tailoring (or individualization) of instruction that accounts for the success of individual tutorial instruction.

- On the basis of empirical evidence, technology-based instruction has been found to be more effective than current classroom instructional approaches in many settings across many subject matters.

- Technology-based instruction is generally less costly than current instructional approaches, especially when many students are to be trained or when instructional objectives require the operation or maintenance of costly equipment.

- Technology-based instruction has been found over many evaluation studies to decrease the time needed to reach targeted instructional objectives by about 30%, thereby preparing personnel more quickly for operational duty assignments and reducing infrastructure costs.

- Remote and massive digital storage technology, combined with global communication capabilities, makes possible the delivery of technology-based education, training, and performance aiding anytime, anywhere.

In brief, a "Rule of Thirds" emerges from assessments of computer-mediated instruction. That is, empirical findings suggest that the use of computer-mediated instruction reduces the costs of instruction by about one-third and either reduces time of instruction by about one-third or increases the amount of skills and knowledge acquired by about one-third.

Given this potential, it is not surprising to find strong international interest in the production and use of computer-mediated learning environments to enhance NATO operational capabilities.

B. Justification

NATO interest in technology-based instruction does not arise solely from cost efficiencies and technological opportunities. Restructuring of military forces in size and composition, along with decreased funding and environmental tolerance for field exercises and practice, has substantially increased requirements for training capabilities such as those offered by computer-mediated environments. These environments can help establish and maintain well-trained, agile forces that ensure commanders ready access to the human performance and competence that are vital for operational success. In addition, they allow forms of training that for reasons of cost, safety, repeatability, and accessibility cannot be provided by any other means.

Military education, training, and performance aiding must prepare individuals to enter into harm's way and perform physically and mentally demanding tasks at the highest possible levels of proficiency in a time-critical manner. This requirement may be the defining characteristic of military pedagogy. With advanced technology available to any buyer, pedagogy and preparation can mean the difference between success and failure, life and death. The necessary pedagogy must be dynamic, allowing continual, just-in-time modification and updating of training environments and materials – especially when these materials are to be distributed anytime and anywhere they are needed. Meeting this requirement requires capabilities for the rapid development of training materials and systems that are maximally responsive to changing operational requirements, readily adapted to cultural differences, and easily used by military personnel.

Technological opportunities that promise to both lower the cost and enhance the speed and agility of preparation, or "authoring," for computer-mediated education, training, and performance aiding have been developed and continue to emerge. These opportunities include authoring templates; authoring that uses pre-stored, reusable, sharable instructional objects, simulation and gaming-based authoring; and "intelligent" automated authoring techniques. The ability of these technologies to enhance the agility and responsiveness of training environments in meeting rapidly emerging and often unforeseen exigencies of modern military operations will save lives and substantially enhance the human competence available to NATO commanders.

II. OBJECTIVES

A. Scope

The Task Group will review and assess:

- The state-of-the-art of authoring systems (e.g., for selection of curriculum content, selection of instructional approaches, design of instruction, efficient development of materials, efficient achievement of targeted instructional outcomes, contributions to operational effectiveness);

- Authoring as it is currently done in the NATO alliance – including the identification and presentation of realistic examples, relevant time constraints, and other considerations that impact the ability to develop learning environments and share their contents;

- Measures of the costs and effectiveness of authoring systems as they contribute to improved operational performance;

- Guidelines for operational application of current and advanced authoring systems;

- Use of simulation and gaming technologies as tools in the authoring process;

- Automated and/or "intelligent" capabilities for authoring;

- Sharable, reusable instructional objects used in authoring; and

- Authoring of performance aiding (as well as instructional) capabilities.

B.   Goals

The goals of the ET will be to describe current capabilities and limitations and their impact on NATO operations. The ET is intended to:

- Increase within the NATO community the awareness of current and emerging authoring capabilities, costs, and effectiveness;

- Identify requirements and capabilities of authoring systems and the computer-mediated environments they produce for usability and interoperability across the NATO nations;

- Identify and prioritize demonstrations, experimentation, and research needed to enhance current authoring capabilities in areas of particular importance in meeting the needs of NATO operations;

- Propose a plan and continuing process for implementing current and emerging capabilities to ensure that they provide maximum and timely benefit to the NATO community; and

- Review what other Research Technology Organisation (RTO) Panels and Groups are doing and opportunities that their activities might offer for inter-Panel coordination and cooperation.

C.   Products

Consistent with its goals, the products of the ET will include:

- Briefings;

- Documentation of existing and evolving capabilities of authoring systems and lessons learned in using them;

- A prioritized research agenda for further Research and Development (R&D) of authoring systems;

- A plan for the implementation and use of authoring systems within the NATO community; and

- Identification of requirements for multi-national interoperability among authoring systems and the computer-mediated environments they produce.

D.   Duration

The ET will operate for 3 years.

III.   RESOURCES

A.   Membership

Membership will include national experts in authoring and instructional systems design, Advanced Distributed Learning (ADL), training simulation for individual and collective training, computer-mediated instruction, NATO operational requirements, training development and implementation, and development and delivery costs of technology-based training and performance aiding.

The ET is expected to include participation from Bulgaria, Canada, Denmark, Germany, Hungary, Italy, Netherlands, Norway, Sweden, the United Kingdom, and the United States. Further participation from nations and from NATO organisations is being sought. Task Group members will include serving military personnel and national experts in simulation technology, behavioural science, computer science, education and training, and development and use of computer-mediated environments.

The Human Factors Medical Panel has selected the United States as the Lead Nation. The United States has designated as Team Leader Dr. Dexter Fletcher of the Institute for Defense Analyses (IDA).

B. National and/or NATO Resources Needed

The work of the Task Group will build on national programmes. Additional resources required will include support for team members, with funding for travel, for participation in working meetings, and for such preparatory work as is agreed.

Access to, and use of, education, training, and performance assets in nations and between nations would also be required to prepare for and then conduct the proposed multi-national demonstration of the potential of mission training through distributed simulation.

NATO support is requested for this Task Group. It should include access to NATO education, training, and performance aiding assets needed to facilitate cooperative efforts and agreements between nations and to provide operational military staff as needed.

C. Research and Technology Agency (RTA) Resources Needed

Funding will be sought from the Cooperative Planning Programme.

Support to establish a website will be requested.

Access to representative software currently being used for authoring; access to knowledgeable, representative users of authoring systems; the ability to participate in teleconferences and email to reduce the need for face-to-face meetings; and the willingness to experiment with advanced authoring techniques to assess technical opportunities, international and cultural issues, R&D priorities and requirements, and NATO operational priorities and requirements.

IV. SECURITY CLASSIFICATION LEVEL

The intent of the Task Group is to operate at the NATO Unclassified level.

V. PARTICIPATION BY PARTNER NATIONS

Partner nations are invited to participate in the Task Group.

VI. LIAISON

Contact and collaboration will be sought with other NATO bodies and Panels.

Annex C – PAPERS, PRESENTATIONS, AND CDs

Boot, E. and Kitchen, D. (2005). "A Model for Selecting Authoring Technologies", Unpublished White Paper Prepared for NATO Research Task Group HFM-129.

Forrester, B. and Verdon, J. (2009). "Introducing Peer Production into the Department of Defense", Unpublished White Paper Prepared for NATO Research Task Group HFM-129.

Kaufman, D. and Lunceford, W.H. (2009). "RealWorld: Simulation Without Programmers (Report NS D-3955)", Alexandria, VA, USA: Institute for Defense Analyses.

NATO Task Group HFM-129 Presentations (September 2005), Los Angeles, CA, USA (Compact Disc).

NATO Task Group HFM-129 Presentations (May 2006), Soesterberg, NLD (Compact Disc).

NATO Task Group HFM-129 Presentations (September 2006), Trenchard Lines, Upavon, Wiltshire, GBR, (Compact Disc).

NATO Task Group HFM-129 Tutorial on Authoring Technologies, Presentation, ITEC Annual Meeting, April 2007, Cologne, Germany.

NATO Task Group HFM-129 Tutorial on Authoring Technologies, Presentation, I/ITSEC Annual Convention, December 2008, Orlando, Florida, USA

Annex D – PRINCIPAL ACTIVITIES

The Task Group (TG) met four times:

1) 20 – 23 September 2005, University of California at Los Angeles (UCLA), United States.

2) 2 – 4 May 2006, Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (TNO) (Netherlands Organization for Applied Scientific Research), Soesterberg, Netherlands.

3) 13 – 16 November 2006, Trenchard Lines, Upavon, Wiltshire, United Kingdom.

4) 4 – 6 April 2007, Cologne, Germany in conjunction with ITEC 2007.

Discussions and presentations of the Task Group activities and findings have been presented to the NATO Training Group (NTG) Joint Services Sub-Group (JSSG) Working Group on Individual Training and Educational Developments at the following meetings:

- April 2005, Copenhagen, Denmark.

- May 2007, Oberammergau, Germany.

- September 2007, Bergen, Norway.

- September 2008, Vienna, Austria.

Other presentations of Task Group findings:

- Authoring Tools Workshop, Fedex Institute of Technology, University of Memphis, Memphis, TN, USA, November 2005.

- Aviation Industry Computer-Based Training Committee Meeting, San Diego, CA, USA, February 2006.

- ITEC Annual Meeting, April 2007, Cologne, Germany, 3-hour seminar – 90 minutes on findings and 90 minutes of hands-on demonstrations.

- Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) Annual Convention, December 2008, Orlando, FL, USA, 90-minute tutorial on Task Group findings and recommendations. I/ITSEC presentation slides are attached to this report.

In assessing the current capabilities and opportunities offered by the state-of-the-art, the Task Group reviewed presentations and demonstrations of the following authoring tools:

- BBN Technologies authoring for DARWARS Ambush! Provides rapid and flexible authoring by local command staff for convoy simulation training.

- Boxer Technologies (now a member of the Edvantage Group) on CourseBuilder. Full enterprise system – web-based and SCORM compatible using templates and drop and drag interfaces.

- Behavioral Technology Laboratories (BTL) / Center for Cognitive Technology (CCT) / University of Southern California (USC) on iRides, ReACT, Personal Knowledge Source (PKS), DIAG. These are all authoring tools providing ease of use and rapid development of simulations and graphical content in them.

- Carnegie Mellon University (CMU) on Cognitive Tutor Authoring Tools (CTAT). Developed by CMU as a set of authoring tools for Intelligent Tutoring Systems (ITS).

- Desire2Learn. A full enterprise system using open standards (Sharable Content Object Reference Model (SCORM) 2004, IMS, IEEE Learning Object Metadata (LOM), and so forth) and interoperable object repositories.

- Epic on Rapid. Template-driven system intended to provide both simple and rapid authoring capabilities, often involving conversion from PowerPoint slides.

- Horizon Wimba on Course Genie. Rapidly and automatically generates SCORM-conformant, online courseware from Microsoft Word and PowerPoint sources.

- Line Communications on Mobile Delivery and Template Driven Authoring.

- Micromedia on Flash, Authorware, Captivate, and Breeze. Full-enterprise solutions for rapid development of materials and maintaining content management through open standards.

- Reload Editor. Provides a drop and drag approach to packaging content so that it conforms to SCORM 2004 specifications.

- Royal Netherlands Army on Flash Template Editor. Intended to imbue media assets with interaction, reusability, and didactical features through the use of adjustable templates.

- UCLA / National Center for Research on Evaluation, Standards, and Student Testing (CRESST) on Assessment Design and Delivery System (ADDS). Tools for authoring student assessments.

- University of Nottingham on Reusable Educational Design Environment and Engineering Methodology (REDEEM). Tool to minimize authoring time and effort by turning already developed content into pedagogically useful learning environments.

- University of Twente on Learn Exact. Provides templates for learning objects, metadata, and packaging.

- USC / Information Sciences Institute (ISI) / Center for Advanced Research in Technology for Education (CARTE) on Tactical Language and Culture Tutor (TLCT). Developed for the Defense Advanced Research Projects Agency (DARPA) by USC's CARTE to provide authoring for game- and simulation-based learning.

- VCom3D on Vcommunicator, Gesture Builder, Scenario Authoring Tool. Authoring tools for developing and synchronizing the actions (e.g., speech, gestures, expressions) of avatars.

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14. Abstract

This report describes and documents the purposes, history, current status, and likely future of capabilities used to design, develop, and maintain computer-mediated environments for education and training. It includes sections on the rapid development of simulations by local commands; development of training simulations for equipment operation, maintenance, and deployment; semi-automated generation of instructional material; and peer techniques using Web 2.0 technologies. Finally, it provides a description and discussion of 26 issues to consider in selecting authoring capabilities. The findings and recommendations of this report are based on the work of representatives from nine NATO countries and Finland.

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