Adaptive Technologies for Training and Education

This edited volume provides an overview of the latest advancements in adaptive training technology. Intelligent tutoring has been deployed for well-defined and relatively static educational domains such as algebra and geometry. However, this adaptive approach to computer-based training has yet to come into wider usage for domains that are less well defined or where student-system interactions are less structured, such as during scenario-based simulation and immersive serious games. In order to address how to expand the reach of adaptive training technology to these domains, leading experts in the field present their work in areas such as student modeling, pedagogical strategy, knowledge assessment, natural language processing, and virtual human agents. Several approaches to designing adaptive technology are discussed for both traditional educational settings and professional training domains. This book will appeal to anyone concerned with educational and training technology at a professional level, including researchers, training systems developers, and designers.

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Preface

Adaptive instruction is instruction that can change to suit the needs of individual learners, with the potential to alter aspects like time on task, content, practice examples, and pedagogical strategy. One-on-one human tutoring is the epitome of adaptive instruction and is the gold standard against which developers of adaptive training technology measure the success of their systems; however, it is unclear which aspects of expert human tutoring are necessary to embed in technology to approximate this benchmark. There are many different ways in which technology could deliver instruction adaptively, but at present, it is not entirely clear (based on empirical evidence) which ways are the most effective in terms of learning outcomes. If we take the example of a television documentary as completely nonadaptive instruction, there are many ways in which adaptation could be added. For example, we could give the student control over the presentation, allowing them to replay or skip parts of the film; or we could allow the student to request subtitles in a different language; or we could follow up the presentation with a question-and-answer period; or we could decide to assign different documentaries to different students, based on an assessment of what they already know. So, an important question is: Which methods of adaptation can be realized in technology, and which are effective at enhancing learning outcomes such that they are worth the extra effort and expense of designing into technology-based training systems?

The purpose of this book is to make a serious examination of what we know and what we do not know with respect to this question. The book is based on a 2009 workshop sponsored by the U.S. Army Research Institute for the Behavioral and Social Sciences. It may be surprising to some that this is a critical question for the U.S. Army; however, many factors have converged to foster an interest by the U.S. Army (as well as other military services) in tailored training enabled by technology. These factors include the nature of the current operational environment and its demand for repeated deployments, which limit time for

formal training; the breadth and diversity of the skills and knowledge soldiers and leaders require, fed by the continual introduction of new equipment and rapidly changing tactics and procedures; a shift in the training paradigm to provide on-demand training; and the size and diversity of the soldier trainee population.

Of these factors, the most compelling is the operational environment. The scope and unpredictable nature of the operational demands on the U.S. military underlie many of the other factors that will shape future training. The U.S. Department of Defense (DOD) Capstone Concept for Joint Operations Version 3 (2009) states that "The future operating environment will be characterized by uncertainty, complexity, rapid change, and persistent conflict" (p. 2). Joint forces will face a range of national security challenges (p. 7) that will require a weighted mix of military actions including combat aimed at defeating armed enemies, security activities to protect and manage civil populations, engagement to improve capabilities of or cooperation with other governments, and relief and reconstruction (pp. 14–18).

Making training more adaptive is a current aspiration within the U.S. Army training community; however, it is important to distinguish three different ways in which the term "adaptive training" is used. One way refers to training people to be adaptable; that is, to train people so that they can respond creatively to unexpected or unfamiliar challenges (Fletcher, 2004; see VanLehn & Chi, Chapter 2, this volume). A second sense in which adaptive training is used concerns the nature of the training bureaucracy and its systems. Traditionally, Army institutional training is based on career tracks, in which, over time, the individual participates in a set of predefined courses linked to promotion steps; however, converting this linear model of training to one allowing more spontaneity and responsiveness to immediate needs makes sense given the unpredictability of future Army missions. The future Army training system aims to become a "learner-centric system of education"(Training and Doctrine Command [TRADOC], 2008). Soldier proficiency and developmental needs, as well as specific operational circumstances and requirements, will be used to shape the content, timing, delivery, and duration of training. This type of instructional adaptability is similar to what Lee and Park (2008) refer to as "macro-adaptive," and what Hannafin and Hill (2008) call "resource-based learning."

The third meaning of adaptive training is the one on which the chapters in this book concentrate primarily. This meaning refers to the ability of training to mold itself to the learner, *within a training episode or event*. It is thus analogous to what Lee and Park (2008) refer to as "micro-adaptive," or what VanLehn (2006) refers to as the "inner loop." From the Army's point of view, less time for training and constraints on resources will necessitate greater reliance on technology-based training. Not only is there less time, but there is a wider skill set to train. The Army is faced with the need to maintain a steady stream of soldiers and leaders trained and ready to perform an ever-increasing set of complex tasks, now including such things as cultural competence, adaptability (both of training environments to individual trainee needs and of trainees to environments they will face in their work), critical and creative thinking, effective team leadership, and effective use of new equipment and information technologies. The vision for micro-adaptive technology-based training is that it will be responsive to time constraints by tailoring training to the learner's current level of knowledge or skill and by applying principles of learning science, thus making training more efficient. The intent is to accelerate learning compared to more traditional modes of training and/or to increase the percentage of trainees achieving standards-based mastery. It is also to enhance the availability of training for the entire training audience, by reducing reliance on face-to-face training and increasing it on technology-based techniques. The aim is to ensure that the best methods are used to give the military learner just what

is needed, when it is needed, and where it is needed (Scales, 2006).

With regard to the provision of training on-demand, it is intended that "embedded" training and performance support will provide much of the needed deployed capability for technical and tactical training involving equipment systems. The DOD defines embedded training as "[c]apabilities built into, strapped onto, or plugged into operational materiel systems to train, sustain, and enhance individual and crew skill proficiencies necessary to operate and maintain the equipment" (Pilgrim, 2008, chart 4). However, advances in training technology that adapt coaching, feedback, and content to a soldier's or unit's proficiency level are required to help realize the full potential of embedded training. In addition to embedding training in equipment, distributing learning to a soldier's computer and/or mobile device can greatly increase their access to needed training while at home station or deployed. The Army continues to push in this direction as time for instructor-led classroom training shrinks and the need to optimize the efficiency of training delivered to units grows. The Army envisions that in the future, "[i]n lieu of the subject matter and instructional expertise of trainers, artificially intelligent tutors, coaches and mentors will monitor and track soldier learning needs, assessing and diagnosing problems and providing other assistance, as appropriate" (TRADOC, 2008, p. 118).

Finally, it is important to consider how characteristics of the Army's trainee population drive the need for adaptive training technologies. In fiscal year 2008, the TRADOC's 5 Army Training Centers and 33 schools conducted about 1,500 courses for more than 500,000 trainees. In addition, TRADOC reaches about 90,000 trainees annually via distributed learning. TRADOC faces many challenges to delivery of effective and efficient training across this vast enterprise. In particular, with a trainee population as large and dispersed as the Army's, it is not possible to make on-site, expert human tutors or coaches available to every trainee. Automated intelligent tutors and coaches, integrated into the delivery of distributed learning courses, could cover at least some of this need. Similarly, the characteristics of soldiers, their training and task proficiency inside and outside of their specialty, their operational and leadership experiences, and the skills needed by any given individual soldier or team for a specific mission vary tremendously across individuals across the force. Thus, a one-size-fits-all approach to training may be ineffective and inefficient in meeting individual or team training needs in a timely manner. For this reason, and for the many reasons mentioned previously, TRADOC has made tailored training enabled by adaptive training technology a high priority for science and technology research.

In summary, many factors intersect to make each trainee and their training requirements unique. Adaptive training technologies could respond to this diversity of experience and learning needs by providing dynamic learning environments that adjust to the requirement of the individual soldier. These technologies can help meet the demands created by the current operational tempo to accelerate learning and help keep training current. In lieu of human tutors, intelligent technology-based tutors can help guide trainees and provide assessment of and feedback on their performance.

The U.S. Army training system is at an important crossroads. Fundamental changes, such as those enabled by adaptive training technologies, will be needed to gain the most out of every training opportunity (U.S. Army Memorandum, 2009). The new U.S. Army Training Concept 2012–2020 (U.S. Army, 2009, p.7), drawing on lessons learned from recent persistent and complex operations, concludes that increasing innovation in training will be essential to "*develop the versatile units and agile leaders required for the future*" (emphasis in the original). Advances in adaptive training technologies will make a critical contribution to realization of that concept. Where do those advances need to be to meet these ambitious goals? The purpose of this book is to "plant

a flag in the ground," indicating where the cutting edge of adaptive training technology is today, and determining in which directions it will need to be pushed to meet the Army vision for tomorrow.

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