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Review

Instructional strategies framework for military training systems ☆

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ABSTRACT

In an effort to improve training efficiency, the military has focused much attention on the development of replicable and generalizable training systems. As a result, a substantial number of companies and contractors have spent significant time and money developing a wide-array of simulators, virtual reality programs, and the like. However, many are designed without considering the effectiveness and efficiency of embedded instructional strategies. In response, the current review argues for the creation of improved training systems through the incorporation of a repository of research-based instructional strategies that can be employed across the entire training cycle. Using a grounded theory method, this review consolidates the vast literature on instructional strategies from the fields of education and the cognitive sciences into a coherent framework that can be used to enhance the design of military training systems. In particular, this review is intended to provide a concise, organized, and practical framework for the selection and implementation of research-based instructional strategies relevant to military training goals.

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1. Introduction

Modern homeland and coalition forces operate in a variety of complex, stressful and ambiguous environments (Laurence & Mathews, 2012; Salas, Priest, Wilson, & Burke, 2006). These situations require the ability to adapt to novel situations, make difficult decisions, and solve complex problems in both warfighting and peacekeeping scenarios (Andrews & Fitzgerald, 2010; Van Merrienboer, 2007). To date, training for these environments has best been accomplished using technology-based experiential learning approaches (Raybourn,

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2007). The rationale for such approaches is that computer-based training, including virtual-reality simulation, offers safe, efficient, and effective training that has practical and economical advantages over more traditional methods (O'Neil & Andrews, 2000). Consequently, the United States military has increasingly invested in the development of replicable and generalizable training systems (Department of the Army, 2011; Salas et al., 2006).

In response, a substantial number of companies and contractors (e.g., Science Applications International Corporation, Lockheed Martin, Raytheon) have spent significant resources developing individualized training systems to support this goal. However, many of these emerging systems lack embedded instructional guidance, and are thus more accurately conceptualized as practice platforms as opposed to *training* devices (Nicholson, Fidopiastis, Davis, Schmorrow, & Stanney, 2007). This lack of guidance is likely to lead to both inefficient and ineffective training, largely defeating the intended purpose of implementing technology-based training programs. This is because such minimally guided training environments are not designed according to the cognitive capabilities and limitations of trainees (Kirschner, Sweller, & Clark, 2006). In particular, when novice trainees are not provided with explicit instructional guidance, they are forced to resort to inefficient problem solving strategies, such as randomly searching their limited prior knowledge and engaging in trial-and-error processes (Sweller, 1999). Fortunately, literature from the cognitive sciences and education offers a number of theory-based and research-supported principles for effective instructional design (e.g., Mayer, 2005, 2009; Sweller, 2005). The power of such strategies is that they are based on the structure of human cognition and are sensitive to relevant individual differences, such as prior knowledge. At present, however, these approaches have not been organized within a coherent framework that is accessible to developers of military training systems. Thus, it is not surprising that the selection of strategies for many training systems are often suboptimal or the systems simply provide no instructional support at all (Bell, Kanar, & Kozlowski, 2008; Cannon-Bowers & Bowers, 2009).

The goal of this review is to address this problem by creating an organized framework for the selection of research-based instructional strategies relevant to the military. Specifically, the grounded-theory approach (Wolfswinkel, Furtmueller, & Wilderom, 2011) was used to characterize strategies based on the time at which the strategy is implemented within the training cycle (i.e., pre-training, during-training, post-training), the expertise level of trainees (i.e., novice, journeyman, expert), and the type of knowledge to be trained (i.e., declarative, procedural, conceptual, integrated). The rationale for this categorization scheme is that the framework can be used to select strategies based on factors specific to training goals that are relevant to training outcomes. The following section briefly reviews research demonstrating the need to incorporate appropriate instructional guidance within training systems by considering specific characteristics of trainees and the training environment. Next, the rationale for applying the grounded theory approach is presented, followed by a description of the review process used to develop the framework. Finally, the framework is presented, and its implications for the selection and application of strategies within training systems are discussed. In short, this review is aimed at developing a research-based composite of instructional strategies that can be used to maximize the effectiveness and efficiency of military training systems.

1.1. Importance of adaptive instructional guidance

There is overwhelming evidence that direct instructional support is a necessary component of optimal training environments, particularly for novice trainees (Kirschner, Sweller, & Clark, 2006; Mayer, 2004). As trainees build expertise within a domain, instruction should then be adapted accordingly to avoid redundant or unnecessary guidance (e.g., Renkl & Atkinson, 2003). This basic idea is the key component of a learner-centered approach to instructional design – basing the selection of instructional strategies on what is known about human cognition, and in particular, the role of trainees' prior knowledge in learning new material. Although this approach is well supported in the literature, military training systems are often not designed accordingly. Rather, such systems often employ minimally guided approaches (e.g., discovery learning, constructivist approaches, problems-based learning, experiential learning, inquiry-based; see Kirschner, Sweller, and Clark (2006) for a critique of such approaches). These approaches assume that learners are able to discover training principles by solving problems and constructing knowledge on their own, without the aid of an instructor or other form of instructional support. However, this rationale ignores the known capabilities and limitations of human cognition, and the results of randomized, controlled experiments have consistently shown such training environments to be inferior to more direct or guided instructional approaches (Kirschner, Sweller, & Clark, 2006; Plass, Moreno, & Brunken, 2010). Further, it is only after trainees have acquired sufficient domain knowledge when less direct approaches become optimal – that is, once trainees have developed expertise, they can effectively solve problems on their own without relying on explicit guidance (Kalyuga, Ayres, Chandler, & Sweller, 2003). In any case, the development of expertise is a gradual process, and thus, instructional guidance should be adapted along the way (Walsh, Moss, Johnson, Holder, & Madura, 2002). Based on this analysis, it is clear that the design of training systems will be most optimal when (a) explicit instructional guidance is provided to novice trainees and (b) when guidance is gradually adapted in line with the development of trainee expertise. Thus, the purpose of this review is to present and describe the instructional strategies that have been shown to help support this goal.

In addition to prior knowledge, the type of knowledge to be trained is also an important consideration in the selection and implementation of instructional strategies. Knowledge has been classified in several different ways but generally consists of facts, procedures, concepts, strategies, and beliefs (e.g., Bloom, 1956; Krathwohl, 2002). For the purposes of this review, knowledge type is classified in a similar fashion: declarative knowledge, which refers to knowledge of basic facts; procedural knowledge, which refers to knowledge of steps to complete a task; conceptual knowledge, which refers to knowledge of the relationship between elements of information; and integrated knowledge, which refers to knowledge that is capable of being applied to novel situations. In other words, at one end of the spectrum, declarative knowledge consists of relatively disconnected facts, best acquired through strategies that facilitate rote memorization; at the other end of the spectrum, integrated knowledge consists of information that can be assimilated with trainees' existing knowledge, best acquired through strategies that facilitate deep understanding of the material. Thus, different training environments have very different goals in terms of the types of knowledge that is to be targeted. Further, different instructional strategies are more appropriate for supporting different types of knowledge (Koedinger, Corbett, & Perfetti, 2012). Therefore, one of the goals of this review is to facilitate the selection of instructional strategies based on the specific type of knowledge associated with the goals of the training environment.

1.1.1. Education and training

Another important consideration in designing adaptive instruction is the applicability of strategies primarily designed for improving academic learning to enhancing military training outcomes. Fortunately, research has suggested that cognitive