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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.

Contents

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 instructional theories and methods more targeted toward the context of academic learning (e.g., cognitive load theory, the cognitive theory of multimedia learning, and expertise development) can be applied toward enhancing military training (Vogel-Walcutt et al., 2010; Williams, Ericsson, Ward, & Eccles, 2008). For example, Vogel-Walcutt et al.,(2010) used a process model of learning to identify strategies (1) aimed at facilitating the cognitive processing necessary for learning and (2) relevant for achieving military training goals. Recommendations included providing an advance organizer prior to training (e.g., Fiore, Hoffman, & Salas, 2008), providing worked examples of problems rather than conventional problem solving practice (e.g., Darabi, Nelson, & Palanki, 2007), and providing metacognitive prompting during training (e.g., Cuevas, Fiore, Bowers, & Salas, 2004). Additionally, recent studies have shown that instructional strategies originally designed for academic learning can be effectively applied to enhance military training outcomes (e.g., Fiorella, Vogel-Waluctt, & Schatz, 2012, Fiorella, Vogel-Waluctt, & Fiore, 2012; Fiore et al., 2008). For example, in one study by Fiorella, Vogel-Waluctt, & Schatz (2012), the modality principle of multimedia learning (i.e., text should be spoken rather than printed when accompanying other visuals; e.g., Mayer, 2009) was applied toward the provision of real-time feedback during simulation-based training of a military Call for Fire task. Consistent with the modality principle, the study showed that providing spoken feedback during training resulted in improved performance on a subsequent transfer task, during which no feedback was provided. Overall, instructional theories and methods from cognitive psychology and education offer much promise to effectively inform the design of military training environments (Vogel-Walcutt et al., 2010; Williams et al., 2008).

At the same time, there are also important differences between instruction in the classroom and instruction designed to enhance military training (Vogel-Walcutt et al., 2010; Laurence & Mathews, 2012). Perhaps the primary distinction can be made with regards to training efficiency and cost-effectiveness (Fletcher, 2009). Specifically, military training is generally more concerned with the same training outcomes being achieved in a timely and inexpensive manner – that is, effective training in the military may mean the same learning outcomes achieved in less time. In contrast, educational goals are aimed at helping students make consistent (as well as efficient) progress acquiring knowledge, with relatively less emphasis on cost-effectiveness. In other words, education tends to set continuous, progressive goals on students, whereas military training tends to place more definite and specific goals on trainees. However, in the context of the current review, such a difference in goals alone is unlikely to translate into the selection of different instructional strategies. This is because instructional strategies designed in accordance with human cognitive architecture often result not only in more effective (i.e., improved performance) but also more efficient (i.e., less time) learning outcomes (Sweller, 1999; e.g., the worked-out example effect, Sweller, 2006). In short, instructional design appears most optimal when it is based on an understanding of human cognition.

Another important distinction to consider between education and training is that military operations often involve units or teams (Salas, Bowers, & Cannon-Bowers, 1995; Salas et al., 2008). Thus, in addition to individual knowledge acquisition and performance, members of a team must possess coordinated goals and skills, as well as have the ability to communicate effectively with each other during missions (Salas, Cook, & Rosen, 2008). Although this is an important aspect of military training, the current review is focused on the acquisition of knowledge (i.e., of facts, procedures, and concepts) essential for all trainees, regardless of whether outcomes are ultimately based in terms of individual or team performance. In other words, this review is focused on how to help individuals (or groups) acquire and be able to apply necessary knowledge and skills for coordinating and communicating effectively in team-based operations (for reviews on team training see Salas, Cook, and Rosen (2008) and Salas et al. (2008)). Overall, the instructional strategies identified in this review are intended to represent general instructional practices based on cognitive theory that have clear implications for enhancing training and applied performance.

In summary, it is important for the design of military training systems to progress from a technology-based approach, which provides minimal guidance to trainees, to a learner-centered approach, which employs instructional strategies that are consistent with trainees' cognitive architecture and the specific goals of the training environment. In order to facilitate this shift, the current review provides a framework of research-based instructional strategies organized around the learner-centered approach. Specifically, a grounded theory method was followed to help categorize the vast literature on instructional strategies and condense them based on their relevancy to military training contexts. The following section provides our rationale for applying grounded theory and describes the process of our review.

2. Grounded theory

Grounded theory offers a method of systematically analyzing large amounts of data into a more concise and usable format. Although many variations of the theory are reported in the literature, there is some consensus regarding its general features: (1) openness throughout the study (2) immediate and continued assessment during the analysis and data collection period, (3) coding, comparing, memo-writing during analysis, (4) theoretical sampling until saturation, and (5) production of a substantive theory (Sbaraini, Carter, Evans, & Blinkhorn, 2011). In short, grounded theory is a useful method for making sense of large amounts of overlapping, yet currently unorganized, information thus, this method offers one potential solution for consolidating and organizing the vast literature on instructional strategies into a practical framework.

2.1. Review process

Two academic databases were utilized to search the available literature on instructional design across multiple disciplines (e.g., social sciences, Science, Technology, Engineering, and Math [STEM], humanities). Both databases were mined for search terms related to instructional design, training, and learning from multimedia: "instructional design," "instructional strategies," "instructional effects," "multimedia learning," "instructional principles," "training methods" (and other logical alternatives, e.g., "instructional design principles," "training strategies," etc.). Results were limited to peer-reviewed research articles published between the years 2001–2011, related to adult education (excluding special education populations), and deemed relevant to military training. Full text articles were located, scanned, abstracted, and entered into a database. In total, 910 unique articles were reviewed for instructional strategies. Articles without instructional strategies or with strategies not relevant to military training, such as those specific to academic subjects or those otherwise unrelated to military training goals, were discarded, leaving total of 589 for review. In keeping with the iterative nature of Grounded Theory, data selection continued during the analysis stage until saturation of categories was reached.

Reviewers were individually and randomly assigned articles to process by reading and highlighting findings and insights pertinent to military training. Each article was systematically examined

Table 1
Pre-training instructional strategies.

Training event	Instructional strategy	Instructional principle	EX	KT	Example citation(s)
Preparation	Goal setting	Establish clear and specific training goals based on trainees' current level of knowledge, skills, and abilities	N	D, C	Eccles and Wigfield (2002)
	Advance organizers	Provide learners with relevant background information prior to learning in order to facilitate the integration of newly acquired information with prior knowledge	N	I	Lin et al. (2006)
	Pre-training	Define and describe key terms of training material prior to presenting the more complex conceptual relationships between the terms	N	D, C	Kester et al. (2006)

Note: EX = Expertise Level (N = Novice, J = Journeyman, E = Expert); KT = Knowledge Type (D = Declarative, P = Procedural, C = Conceptual, I = Integrated).

using an iterative and intertwined procedure of open, axial and selective coding to excerpt and assess relevant portions of the text. The open coding process constituted the first abstraction layer, in which the reviewer read and re-read each study until a number of well-defined concepts started to emerge from the underlying data, which could be distilled iteratively into categories in the later coding steps. Forward and backward citations from the readings (an iteration of the select stage) elicited numerous articles that described different categories of instructional events implemented for various educational purposes. During open processing, the primary goal was to elicit concepts from articles through a repetitive review process. Articles were then cross-reviewed in order to allow all reviewers familiarity with the data for comparing and analyzing the initial concepts and to aid category generation during the next two coding processes. The axial and selective coding steps jointly proved to be the most integrated and iterative processes of the Grounded Theory review process. Axial coding involves the development of categories and sub-categories. Selective coding involves integration and refinement of the categories. Finally, the concept matrix created during the analysis stage formed the framework for the presentation of instructional strategies identified in this review. The next section describes the categories and sub-categories that were used to frame the instructional strategies relevant to military training.

3. Results

Tables 1–3 present the results of the review based on the framework identified during the grounded theory analysis. In total, 23 instructional strategies most relevant for the design of military training systems were identified, including 3 pre-training strategies, 17 during-training strategies, and 3 post-training strategies. Each instructional strategy is defined in terms of a general research-based instructional principle based on the literature. Strategies were further organized within the framework based on the following variables revealed by grounded theory: instructional event (e.g., prepare the trainee, present information, provide guidance, and promote reflection), expertise level (i.e., novice, journeyman, and expert), and the to-be-trained knowledge type (i.e., declarative, procedural, conceptual, and integrated). Finally, representative citations are provided for further detail regarding how each strategy can be effectively implemented.

3.1. Pre-training strategies

The review identified three primary instructional strategies for implementation prior to training: goal setting, advance organizers, and defining key terms (see Table 1). First, goal setting involves clearly presenting trainees with the goals of the training task before it begins. Setting specific and reachable goals prior to training is meant to help motivate trainees to focus on the most relevant material during training and to select appropriate learning strategies that will assist in achieving those goals (e.g., Eccles & Wigfield, 2002). Second, advance organizers can be used to activate trainees' relevant prior knowledge before being presented with new material. Specifically, advance organizers help trainees integrate their existing knowledge with newly presented training material (e.g., Lin, Dwyer, & Swain, 2006). Finally, defining key terms provides trainees with background information on important facts and concepts before presenting the more complex relationships between those facts and concepts during training. Rather than being forced to devote cognitive resources towards figuring out what key concepts mean during training, this form of pre-training allows trainees to instead focus on organizing the information and integrating it with their prior knowledge (e.g., Kester, Kirschner, & van Merrienboer, 2006). Overall, the purpose of pre-training instructional strategies is to focus trainees on the most important material, activate relevant prior knowledge, and provide them with the necessary background knowledge prior to training.

Each of the strategies described are primarily targeted towards novice trainees who lack existing domain knowledge, and therefore, would be most benefited by setting goals, activating relevant general knowledge, and being provided with background information. Those with higher levels of domain knowledge are unlikely to be benefited by pre-training strategies. Pre-training instructional strategies can be used to facilitate the acquisition of declarative and conceptual knowledge in the case of goal setting and defining key terms, as well as integrated knowledge, in the case of providing an advance organizer. In short, pre-training instructional strategies are targeted toward novice trainees and can be used to facilitate different types of knowledge acquisition, depending on specific training goals.

3.2. During-training instructional strategies

Seventeen during-training instructional strategies were identified, which were further classified into three sub-categories: information presentation (8), providing guidance (7), and practice (2) (see Table 2). Much of the strategies related to information presentation and guidance were derived from research grounded in two major theories of learning and instructional design: cognitive load theory (Sweller, 1999, 2005; see Plass et al. (2010) and Sweller, Ayres, and Kalyuga (2011) for reviews) and the cognitive theory of multimedia learning (Mayer, 2011; see Mayer (2009) for a review). These theories suggest that (1) training materials should be presented in a way that is consistent with human cognitive architecture (i.e., the structure of working and long-term memory) and (2) guidance should be provided in accordance with trainees' existing level of expertise. Finally, trainees should engage in practice training exercises that are deliberately aimed at mastering specific skills and that are distributed over time.

Table 2
During-training instructional strategies.

Training event	Instructional strategy	Instructional principle	EX	KT	Example citation(s)
Presentation	Multimedia	Present training materials using pictures and words rather than words alone	N	C, P, I	Moreno and Valdez (2007), see Mayer (2009) for a review
	Spatial/temporal contiguity	Integrate words and pictures spatially rather than presenting them spatially separated. Present words and pictures concurrently rather than separated in time	N	C, I	Bodemer et al. (2004), see Ginns (2006) for a meta-analysis
	Segmenting/ sequencing	Segment or sequence complex material by presenting the material in manageable 'chunks'	N	C, I	Mautone and Mayer (2007)
	Modality	Present words in spoken form rather than text when accompanied with concurrent visuals	N	C,I	Leahy, Chandler, and Sweller (2003), see Ginns (2005) for a meta-analysis
	Signaling	Emphasize the most important training material by providing visual (e.g., arrows, animations) or auditory cues	N	D, C	Stull and Mayer (2007), see de Koning, Tabbers, Rikers, and Paas (2009) for a review
	Personalization	Present words in conversational rather than formal language during multimedia training	N	I	Moreno and Mayer (2004) and Wang et al. (2008)
	Animation	Use segmented and realistic (e.g., video-based) animations when training procedural-motor skills	N, J	P	See Hoffler and Leutner (2007) for a meta-analysis
	Analogizing and concretizing	Present training material in a context that is familiar to trainees to facilitate the integration of the material with prior knowledge	N, J	I	Moreno, Mayer, Spires, and Lester (2001)
Guidance	Worked out examples	Explicitly present and explain to novices all of the steps required for solving a problem rather than requiring them to solve the problems on their own	N	D, P	Atkinson (2002), Renkl and Atkinson (2002), see Van Gog and Rummel (2010) for a review
	Faded examples/ completion problems	As trainees develop expertise, begin to require them to solve solution steps to problems on their own rather than providing the steps explicitly	J	P, C, I	Renkl and Atkinson (2002) and Renkl and Atkinson (2003)
	Conventional problem solving (minimally-guided instruction)	At the expert level, provide trainees with conventional problem-solving practice rather than explicitly providing any of the solution steps	E	C, I	Atkinson et al. (2003) and Kalyuga et al. (2001)
	Cognitive apprenticeship	Guide trainees during real-world training tasks by explicitly modeling appropriate cognitive processing, providing hints and feedback, and assisting when trainees are unable to complete parts of the task on their own	N, J	P, C, I	Slavin, Hurley, and Chamberlain (2003), see Slavin (2011) for a review
	Immediate feedback	Immediately following errors made during problem solving, provide novice trainees with corrections, hints, or explanations to help them solve the solution step correctly	N, J	P, C	Koedinger and Aleven (2007)
	Explanatory feedback	Address trainee errors by explaining the rationale behind correct solutions (i.e., explanatory feedback), rather than only informing trainees whether their solution was right or wrong (i.e., corrective feedback)	N, J	C, I	Moreno (2004), see Shute (2008) for a review
	Metacognitive prompting	Provide trainees with prompting that encourages them to reflect on their own understanding of the material and select appropriate learning strategies	N, J	C, I	Fiore et al. (2008)
Practice	Deliberate practice	Provide trainees with many opportunities to engage in practice exercises, during which provide specific feedback to help trainees develop mastery of the skill	N, J	P, C, I	See Ericsson (2002) and Ericsson (2006) for reviews
	Distributed practice	To maximize long-term learning, distribute practice over multiple, short training sessions that are separated in time, rather than massing practice all at once	N, J	D, P, C	Pavlik and Anderson (2008)

Note: EX = Expertise Level (N = Novice, J = Journeyman, E = Expert); KT = Knowledge Type (D = Declarative, P = Procedural, C = Conceptual, I = Integrated).

3.2.1. Information presentation

Regarding information presentation, the multimedia principle of instruction states that training is enhanced when materials are presented using words and pictures rather than words alone. This is because presenting training materials in visual and auditory form takes advantage of the "dual-channels" structure of working memory for visual and auditory processing, allowing more cognitive resources to be devoted towards organizing the material into a coherent cognitive structure and integrating that information with prior knowledge (Mayer, 2009). Further, visual and auditory materials should be presented in close proximity in both time and space (i.e., spatial/temporal contiguity) and that words should be presented in spoken rather than text form when accompanied by concurrent visuals (e.g., Bodemer, Ploetzner, Feuerlein, & Spada, 2004; see Ginns, 2006 for a meta-anlysis). For complex material, training outcomes are enhanced when the material is broken down into manageable and independent "chunks" rather than presenting all of the material at once (e.g., Mautone & Mayer, 2007; i.e., signaling/sequencing principle).

Overall, instructional strategies for effective information presentation are primarily targeted towards novice trainees. This is because poor information presentation can cause extraneous

Table 3
Post-Training Instructional Strategies.

Instructional event	Instructional strategy	Instructional principle	EX	KT	Example citation(s)
Assessment	Testing	Use assessments as training tools by testing trainees on the material	N, J	D, C	Roediger et al. (2006), Johnson and Mayer (2009), see Karpicke and Grimaldi (2012) for a review
Feedback	After-action reviews	Provide a summary of trainees' performance following completion of a training task; include corrective and explanatory feedback, as well as suggestions for performance improvement	N, J, E	C, I	Stevens-Adams et al. (2010)
Reflection	Reflective prompting	Prompt trainees to reflect upon their own training outcomes and to consider ways in which they could improve their performance	N, J, E	I	Moreno and Mayer (2005)

Note: EX = Expertise Level (N = Novice, J = Journeyman, E = Expert); KT = Knowledge Type (D = Declarative, P = Procedural, C = Conceptual, I = Integrated).

processing (i.e., processing which is irrelevant for learning), which risks overloading trainees' very limited capacity to process and make sense of new information (Mayer, 2009). Since experts possess large amounts of domain knowledge that they can apply with relatively low cognitive effort, they are unlikely to be affected by poor information presentation during instruction. In other words, they can efficiently discern what is important, what can be ignored, and where to file information in long term memory. Information presentation effects have also been found across training different types of knowledge, with strategies such as signaling targeted toward the acquisition of lower-level declarative knowledge and strategies such as using multimedia and animation targeted at higher-level conceptual and integrated knowledge. In short, information presentation strategies are essential for novice trainees to help limit unnecessary cognitive demands during training.

3.2.2. Instructional guidance

Regarding instructional guidance, the nature and amount of guidance provided to trainees should be determined based on their current level of expertise. This idea can be best demonstrated by the vast amount of research on worked examples (e.g., Atkinson, 2002; Renkl & Atkinson, 2002), which has largely been conducted within the framework of cognitive load theory (Sweller et al., 2011). Worked examples are problems presented with every step of the solution explicitly shown and described. Research has repeatedly shown that providing worked examples to novices is superior to having students practice solving the problems on their own (e.g., Van Gog & Rummel, 2010). As trainees develop in expertise, however, it is necessary to incrementally reduce the amount and type of guidance provided. Specifically, rather than providing fully completed examples, trainees could be provided with faded examples, which progressively reduce the number of solution steps provided in order to promote independent problem solving (e.g., Renkl & Atkinson, 2002, 2003). At the highest expertise level, fully independent problem solving practice is the most beneficial (e.g., Atkinson, Renkl, & Merrill, 2003; Kalyuga, Chandler, Tuovinen, & Sweller, 2001).

Other instructional guidance strategies include providing feedback or prompting during training. Regarding feedback, novice trainees benefit most when it is provided in explanatory rather than simply corrective form (e.g., Moreno, 2004; see Shute (2008) for a review). In other words, feedback should explain the reasons why trainees' actions are correct or incorrect, rather than providing feedback that only informs trainees that they are right or wrong. Explanatory feedback provides novice trainees with explicit instructional support rather than the to evaluate their own performance. In contrast, detailed explanations may be unnecessary for more expert trainees, in which case simply providing corrective feedback may be more appropriate. Similar to providing feedback, trainees also benefit from being prompted to reflect on their own performance or understanding of the material during training. In particular, providing various forms of metacognitive prompting, such as questioning or self-explanation prompting, has been shown to effectively improve training outcomes (e.g., Fiore et al., 2008). Metacognitive prompts encourage trainees to reflect upon their current understanding of the training material. Further, prompting promotes the selection and implementation of appropriate learning strategies. Overall, feedback and prompting are most beneficial for trainees at the novice and journeyman levels and training higher-level conceptual and integrated knowledge.

3.3. Post-training instructional strategies

Three primary post-training instructional strategies were supported in the literature: testing, after-action reviews, and reflective prompting (see Table 3). First, assessing trainees through testing can also serve as an effective instructional strategy (i.e., the testing effect). Testing provides trainees with practice retrieving information from long-term memory, which consequently, strengthens the materials' memory trace (e.g., Roediger & Karpicke, 2006). This retrieval practice also simulates the procedures trainees must conduct when solving real-world problems. Overall, the testing effect has been well supported in the literature as superior to other common training strategies (e.g., repeatedly reviewing materials); however, more work is needed to investigate the extent to which the testing effect applies to more authentic training environments (e.g., Johnson & Mayer, 2009). Second, reflective prompting can be used to encourage trainees to reflect on the quality of their performance during training and consider ways in which they could improve their performance (e.g., Moreno & Mayer, 2005). The rationale for this strategy is similar to that of providing metacognitive prompting during training. Post-training reflective prompting is potentially effective for all levels of expertise, depending on the level of support provided during training. For example, novices or journeymen provided with during-training metacognitive prompting may also benefit from being given reflective prompting following training. On the other hand, experts spared of unnecessary and potentially distracting prompting during training may benefit from prompting occurring after training materials have been presented. Finally, after-action-reviews are a form of delayed feedback that summarize the performance of trainees following the training task (e.g., Stevens-Adams, Basilico, Abbott, Gieseler, & Forsynthe, 2010). Similar to reflective prompting, after-action-reviews can supplement support provided to novices or journeymen during training. In contrast, after-action-reviews can serve as the primary form of support to experts. Overall, testing, reflection, and after-action-reviews differentially affect trainees of different levels of expertise.

4. Discussion

The primary purpose of this review was to create a coherent framework for selecting instructional strategies based on specific training environment characteristics relevant to the military. In particular, the framework is meant to be (1) concise – in that it has condensed the literature into the most relevant research-based instructional strategies; (2) organized – in that each strategy has been categorized in terms of its specific role within the instructional process; and (3) practical – in that it provides a set of general instructional design principles that can be implemented to improve the design of training systems. Using the grounded theory approach, a vast literature of instructional and training strategies could be condensed into a concise, organized collection of general principles that can be practically applied to meet the demands of varying training goals. In the process, the consistent theme from the literature is that instructional strategies must be informed by an understanding of human cognitive architecture and that trainees' prior knowledge is the most important consideration for effectively instructional design. By using this theme to drive the construction of our framework, the strategies presented are not only likely to be effective across training environments, but they are also intended to be cognitively efficient. In terms of military training, this translates into enhanced learning outcomes achieved in a timelier, and thus more cost-effective, manner – an essential goal for training systems developers.

Overall, the framework presented in this review represents the core of research-based instructional design principles relevant for the design of military training systems. In particular, this review provides developers of training systems with a set of practical strategies to achieve instructional goals throughout the entire training cycle. Regarding pre-training, the goal of instruction should be to prepare novice trainees for learning by activating prior knowledge, setting clear goals, and providing relevant background knowledge. For example, providing an advance organizer to novices activates their relevant existing knowledge so that it can be more easily integrated with the material presented during training. The goals of instruction during training should be to present information in a way that is consistent with how trainees process and learn new material and to provide guidance based on trainees' current level of expertise. Regarding information presentation, using multimedia materials (i.e., pictures and words) rather than words alone takes advantage of trainees' two channels for processing visual and verbal material, thereby maximizing the efficiency of their limited capacity to process new information. Regarding instructional guidance, trainees should first be provided with explicit support, then guided through real-world problem-solving scenarios, and finally, given opportunities to independently practice solving-problems in novel situations. Finally, the goals of post-training instruction should be to assess trainees, encourage reflection, and provide detailed summaries of trainee performance. For example, trainees may be asked to reflect on how they can improve upon their performance in a future training task. In short, the framework constructed by this review provides clear recommendations for selecting and implementing appropriate instructional strategies at all stages in the training process.

4.1. Limitations and future research directions

One potential limitation of this review is the lack of direct empirical testing of the strategies presented in the framework within military training contexts. The extant literature in this area has predominately been tested in relatively brief laboratory studies that were mainly focused on testing the strategies within the context of academic learning. For example, much of the work based on the cognitive theory of multimedia learning (Mayer, 2009, 2011) and cognitive load theory (Sweller, 1999, 2005; Sweller et al., 2011) – which has identified several principles of instructional design – has followed this lab-based, academic learning approach. Consequently, the impact of these strategies applied to real-world military training contexts, has not yet been fully tested. However, despite this limitation, there are two primary reasons the design principles identified by research is expected to be equally impactful for knowledge acquisition and application. First, the instructional design principles presented are intentionally broad and based on basic, well-known principles of human cognitive architecture. For example, it is clearly established that humans possess a very limited working memory capacity in which to process newly presented information and a relatively unlimited long-term memory capacity, the contents of which essentially determine how new information is to be acquired. Additionally, recent research has begun testing these strategies in more authentic training environments. For example, in a recent study by Fiorella, Vogel-Waluctt, & Schatz, (2012), the modality principle of multimedia learning (i.e., words should be presented in spoken rather than text form when concurrent visuals are present) was supported for the presentation of real-time feedback during simulation-based training of a complex military decision making task. Further, other recent studies have demonstrated that providing metacognitive prompting during training can improve training outcomes within complex military training contexts (e.g., Fiorella, Vogel-Waluctt, & Fiore, 2012). While these results are encouraging, continuing research is needed to provided further empirical evidence that the same instructional strategies shown to improve academic learning can be used to improve military training.

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