Encouraging Active Learning

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Introduction

Traditionally, trainees have been viewed as rather passive recipients of instruction, with the trainer structuring the learning experience. Active learning approaches, in contrast, view trainees as active participants of the learning process. Active learning has become in part become popular due to technological developments that facilitate more active engagement of trainees (e.g., e-based training methodologies). Secondly, in modern workplaces—which are characterized by frequent change, uncertainty, and less hierarchy—responsibility for one's learning and development is more and more being shifted to the employees themselves. Apart from these practical reasons and necessities, there are also theoretical considerations and empirical evidence in support of active learning. Active learning approaches may lead to better transfer outcomes than traditional training approaches, particularly when the training goal involves adaptability of trained skills to novel tasks and requirements (i.e., adaptive transfer). At the same time, motivationally, active learning approaches may be more challenging, as trainees may be reluctant to take over responsibility for their own learning and as learning may become subjectively more demanding.

This chapter explores active learning approaches as well as benefits and challenges associated with their use in organizational training. We will begin with a discussion of the concept of active learning and an overview of various active training interventions. Subsequently, we will discuss theory and findings regarding the effectiveness of active learning approaches as well as cognitive, motivational, and emotional processes that may underlie their effectiveness. We will also present recent evidence on aptitude-treatment interactions (ATI), that is, interactions of training method and person characteristics (e.g., cognitive abilities, personality) that may inform us who benefits most—or least—from active learning. The chapter shall close with a discussion of future research directions related to active learning in organizations, which includes research on informal active learning activities in organizations as well as their predictors and outcomes.

Conceptual background: What is active learning?

Although active learning as a concept is becoming increasingly popular, there is no generally agreed use of the term 'active learning'. Active learning is usually described as an approach that ascribes the trainee an active role in the learning processes, for example, exploratory training in which trainees explore and experiment with the training tasks. Additionally, active learning is often contrasted with more traditional, more proceduralized, and more structured approaches that view trainees as rather passive recipients of instruction (Bell & Kozlowski, 2010; Keith &

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Frese, 2005). The lecture may be regarded a prototypical example for traditional instruction; another example is proceduralized training that is based on step-by-step guidance through the training material and tasks. While at first sight the definition of active learning and its differentiation from traditional instruction may appear to be clear-cut, there remains quite some fuzziness about the concept. First, it is not clear what is meant by the term 'active' or 'activity' in active learning. For example, activity can imply *behavioral* (i.e., observable) activity by the trainees, that is, rather than listening to a one-way lecture or watching a trainer perform correct actions, trainees are required to do something during training themselves (e.g., individual experimentation with the task, a group exercise in class). Other conceptions of active learning focus on *cognitive* (i.e., not directly observable) activities of trainees during training. This conception becomes apparent in cognitive constructivism which views any learning as active knowledge construction and construction of meaning (e.g., Bruner, 1966). According to this view, knowledge cannot be transmitted from some agent to another (e.g., from the trainer to trainees, from the teacher to students) but needs to be "actively built up" by some "mental activity of learners" (Driver, Asoko, Leach, Mortimer, & Scott, 1994, p. 5). In the present chapter, we will primarily focus on active learning involving behavioral activity on part of the trainee—in particular, the activities of exploration and experimentation. We will further propose that cognitive activity—among other processes, such as motivational and emotional processes—function as an important mediator of the effectiveness of active learning approaches (see section 5).

Second, there are different conceptions about the setting in which active learning takes place. A useful distinction in this context is between formal and informal learning (Tannenbaum, Beard, McNall, & Salas, 2010). *Formal learning* refers to planned learning that takes place in a formalized and systematic manner, for example, as part of a training program for employees of an organization. Formal learning activities are usually based on specified learning objectives (i.e., training goals) and have a predefined start and end. *Informal learning* in organizations, in contrast, refers to learning activities that do not have a clearly defined start and end point and that take place in an unsystematic und unstructured way, for example, by observing or asking more experienced colleagues at work or by performing a challenging and new work task (Sonnentag, Niessen, & Ohly, 2004; Tannenbaum et al., 2010). An example for active learning as part of formal training is a training method called error management training (Frese et al., 1991). Error management training is based on the assumption that errors are a natural part of the training processes and may be even useful in learning and mastering a task; trainees are therefore provided with only little structure by the trainer and are encouraged to make errors and learn from them as they explore and experiment with the training tasks (e.g., Heimbeck, Frese, Sonnentag, & Keith, 2003; Keith & Frese, 2005, 2008). An example of an approach that focuses on active learning as part of informal learning at work (i.e., outside formal training settings) is the job demand-control model by Karasek and colleagues (Karasek & Theorell, 1990). This model is much better known for its strain hypothesis, which predicts the development of strain as a reaction to high job demands and low job control. Its *active learning hypothesis* proposes that high job demands in combination with high job control and support contribute to on-the-job learning and well-being at work (Daniels, Boocock, Glover, Hartley, & Holland, 2009). Finally, *self-regulated learning* may be positioned somewhat in-between formal and informal learning. Self-regulated learning implies that learners actively shape their learning experience as they use various cognitive and metacognitive strategies to control and regulate their learning (Zimmermann, 1990). Like formal learning, self-regulated learning is systematic and has a clearly defined goal; unlike formal learning, however, and more like informal learning, it may not have a clear starting and end point and it is not structured by a trainer or the organization but by the learning individual herself/himself.

Finally, a number of group learning approaches or, more specifically, collaborative learning methods are being discussed in educational psychology. These may be termed active learning because individuals actively engage in shaping the learning experience for themselves and for the group. Cooperative learning methods go beyond mere working in groups but assign individuals particular roles within the group. A classical and well researched example is the jigsaw method (Aronson & Bridgeman, 1979). This method assigns every individual to become an expert on some part of the topic to be learned cooperatively. Experts of every group meet before going back to their groups and teaching their group mates about their area of expertise. Some of the more recent cooperative learning approaches incorporate technological developments (e.g., social interactions in the web, communication via mobile devices) to enhance group learning (e.g., Hsu & Ching, 2013).

Taken together, an array of approaches may be or have explicitly been termed active learning approaches. While these approaches all have in common the view of the learner—be it the worker, trainee, or student in the classroom—as active agent of the learning experience, there are considerable differences between these approaches in terms of the setting and type of learning activities. It is conceivable—although ultimately an empirical question—that these differences are paralleled by differences in the psychological processes that are elicited in learners and that may benefit learning. It is beyond the scope of this chapter, however, to provide an overview and integration of these diverse approaches of active learning. Rather, in line with the topic of this *Handbook*, we will focus on one class of active learning approaches, namely, active learning as part of formalized organizational training. To signify this focus, in the remainder of this chapter we will use the more specific term 'active *training*' instead of the broader term 'active *learning*'. The next section will describe in more detail the characteristics of active training interventions that have been or can be used for training in organizations.

Designing active training: An overview of active training interventions

All active training interventions engage learners with the training material in some way. Yet, there are considerable differences in how this active engagement of learners is achieved or, in other words, in the design of the training. In this section, we will first propose basic dimensions of active training interventions. These dimensions describe characteristics of training design that all interventions share although the magnitude may differ (section 3.1, Table 6.1). Second, we will describe supplemental components of active training interventions which some applications incorporate as an addition to the basic dimensions (section 3.2; Table 6.2).

Basic dimensions of active training interventions

Exploration and experimentation. A major ingredient of active training is active exploration and experimentation by trainees during training. In active training, rather than receiving detailed step-by-step guidance about correct procedures as in traditional proceduralized training, participants actively explore the training material on their own. Error management training is an example for an active training intervention that extensively uses exploration during training. For example, in a computer software training, participants receive only minimal information on the basic functions of the program and otherwise work independently on training tasks (Frese et al., 1991; Keith & Frese, 2005, 2008). Another way to implement experimentation is to have participants explore simulations. For example, in a study by (Olympiou, Zacharias, & deJong, 2013), participants interacted with materials (e.g., a light source) and observed the outcomes of their actions (e.g., shadows or colored light). Finally, a number of studies have used a dynamic decision making task in which trainees experimented with the task, developed strategies, and tested their effectiveness (Kozlowski et al., 2001).

Table 6.1

Basic Dimensions of Training Design of Active Learning Interventions

Dimension	Description	Typical
Exploration and experimentation	How knowledge is acquired, i.e., •by performing instrumental behavior such as exploration and experimentation	High; exploration and experimentation are core elements of active learning
Amount of information provided	How much information is provided to learners beyond exploration and experimentation	Low; information needs to be acquired through exploration and experimentation
Form of provision of information	How and when information is provided •prior to the active phase (instruction) •permanently during training (support) •as an individualized evaluation of performance and strategy (feedback)	General information is provided at all times; step-by-step instructions are not available at all
Learner control	How much control learners have on the •sequence of tasks •elaboration of strategies •selection of actions	High; learners explore and experiment based on individual choice
Level of difficulty throughout the intervention	How difficult tasks are and whether difficulty changes throughout the training	High

Amount of information provided. Active learning interventions often provide only little task information. Rather, trainees are encouraged to explore and infer the information that is necessary to solve the training tasks. For example, in error management training only little information is given to trainees. In error management training (Frese et al.,1988), novices had to learn how to use a word processing program without an introduction to the software and without access to a manual but only a list of possible commands. Participants were encouraged to develop and test hypotheses about what commands to use to solve the training tasks. Other studies provided more information to participants, although usually less information than is provided to trainees of traditional guided training. Next, we will describe different ways of how and when such information may be provided during the course of training,

Methods of provision of information. In active training, information may be provided (a) prior to the practice phase (instruction), (b) it may be made permanently available during training (support), or (c) it may be delivered in terms of individualized evaluation (feedback).

I. ***Instruction***. Active training interventions differ in the extent to which they provide pre-training instructions. For example, in a training that taught electronic search skills, participants received sufficient instructions to develop a basic skill level (e.g., overview of the electronic data base, description of effective search strategies). An instructor then demonstrated adequate strategies (Wood, Kakebeeke, Debowski, & Frese, 2000). A number of studies have used a decision-making simulation called TANDEM (Weaver, Bowers, Salas, & Cannon-Bowers, 1995). These studies usually provided to participants a demonstration of the simulation, an operating manual, and a list of training objectives comprising skills and strategies (e.g., Bell & Kozlowski, 2002, 2008; Ford, Smith, Weissbein, Gully, & Salas, 1998; Gully, Payne, Koles, & Whiteman, 2002; Kanar & Bell, 2013; Kozlowski & Bell, 2006; Kozlowski et al., 2001).

II. ***Support.*** Active training often provides information that is permanently available to the learner during exploration and experimentation thus offering support when learners encounter difficulties. By including such support, exploration and experimentation are complemented with assistance in case learners cannot get ahead without further information. Various types of support have been used. In electronic search studies, participants received a summary sheet listing the steps of an adequate search strategy that could be used during practice (Debowski. Wood & Bandura, 2001; Wood et al., 2000). They also had access to an on-line help facility which contained documentation of strategies and solutions. Additionally, a printed version was available on their desk (Debowski et al., 2001). In decision-making studies using TANDEM, learners had repeated access to the operating manual as a fixed part of the practice phase (Bell & Kozlowski, 2008). No matter how support is offered, it may become an essential resource when learners face obstacles.

III. ***Feedback.*** Some training tasks may include task-generated feedback that enables trainees to judge their progress without external guidance. For example, in computer training using modern software packages, the user usually can observe visual changes on the screen that inform him or her whether the goal (e.g., inserting a table in a text) is achieved or not. Accordingly, in error management training of computer skills, no external feedback is provided (cf. Keith & Frese, 2008). In other cases, feedback provided by an external agent (e.g., the trainer) may be necessary. For example, in the aforementioned training of electronic search skills, participants received feedback about performance and strategy. Performance feedback was calculated as the percentage of correctly retrieved search records. Strategic feedback contained expert ratings of several dimensions of their search behavior, i.e., breath, depth, sequence of search, and thesaurus usage (Wood et al., 2000). In the studies mentioned above that used the decision-making simulation, trainees obtained feedback on several important aspects of the task, including basic and strategic performance, after each trial (e.g., Bell & Kozlowski, 2008).

Learner control. Learner control implies that learners are given the opportunity to make "choices in both what and how to learn" (Kraiger & Jerden, 2007, p. 65). These choices may involve aspects such as choice of topic, sequencing of information or tasks, and pacing. At first sight, it may appear that active learning implies learner control because in active learning participants make choices as they independently explore and experiment with the system. While there may be a partial overlap of exploration and choice, the one is not necessarily implied by the other. For example, an instructional software may allow the learner to freely choose the order and pacing of chapters within the instructional program, while each chapter is highly structured and does not allow any exploration. Also, while all active training interventions include exploration to some extent, the degree of unguided exploration and learner control may differ. Some active training interventions reduce learner control, for example, by imposing a given structure on the learner, either in terms of a fixed task sequence (Wood et al., 2000) or a narrow range of choices for the learners as a consequence of prescribed strategies (Debowski et al., 2001). In a study with particularly high control during exploration (Kamouri, Kamouri, & Smith, 1986), participants were confronted with several technical devices (e.g., an alarm-clock). They were instructed to find out how each device worked without receiving any further information. Trainees experimented with the available buttons to discover their corresponding functions. By interacting with the devices, participants explored their functions and inferred the underlying rules by themselves and without any guidance.

Level of difficulty throughout the intervention. Task difficulty during active training varies between studies. In error management training, participants typically work on difficult training tasks, sometimes even with task difficulty increased to levels that rendered success almost impossible (Frese et al., 1991); the idea of presenting difficult tasks in error management training is to ensure that trainees are actually exposed to errors and setback during training—as probably will be the case later in the transfer situation at work—and have the opportunity to develop strategies to deal with them. In a study in which negotiation skills were practiced, confederates intimidated trainees during negotiation to ensure sufficient levels of task difficulty (Stevens & Gist, 1997). Another way to increase difficulty is to include tasks that are both complex and relatively novel for participants (Tabernero & Wood, 1999). Other studies have used relatively easy tasks in the beginning and then progressed to the more difficult ones (Debowski et al., 2001).

Supplemental components of active training interventions

In addition to the basic dimensions that characterize active training interventions, some applications have used supplemental instructional components which will be presented next.

Mastery goal instructions. A mastery or learning goal orientation implies that the learner views the training situation as an opportunity to develop task mastery rather than to demonstrate performance to others (i.e., performance goal orientation; Dweck & Leggett, 1988). In active training interventions, mastery goal orientation has been induced by instructions such as “The more practice you have, the more capable you will become” or “Practice makes perfect” (Martocchio, 1994). Participants were informed that skills develop through practice (Nordstrom, Wendland, & Williams, 1998; Tabernero & Wood, 1999), they were instructed to interpret the practice task as an opportunity to improve their skills (Stevens & Gist, 1997; Wood et al., 2000) and to regard their performance score as helpful feedback (Kozlowski et al., 2001). Later research has incorporated lists of explicitly formulated learning goals (referring to skills, principles, and strategies) that were provided to the participants (Kozlowski & Bell, 2006). Those learning goals usually increase in complexity from basic knowledge goals to strategic objectives (Kozlowski et al., 2001).

Table 6.2

Supplemental Components of Active Learning Interventions

Component	Function	Example
Mastery goal instructions	•Direct learners' motivational orientation toward the attainment of task mastery •Interpret practice as an opportunity for skill improvement	"Practice makes perfect" (Martocchio, 1994)
Error management instructions	•Encourage making errors •Frame errors positively	"Errors are a natural part of learning. They point out what you can still learn" (Dormann & Frese, 1994)
• Emotion control instructions	•Help individuals manage their negative emotions •Emphasize personal control, i.e. a positive 'CAN DO' attitude	"This task may be challenging, but I know I CAN do it" (Bell & Kozlowski, 2008)
• Metacognitive instructions	•Enhance deliberate thought processes targeted on solving problems	"What is my problem? What am I trying to achieve?" (Keith & Frese, 2005)
Adaptive guidance	•Provide diagnostic and interpretive information where to direct further effort •Adaptively suggest which skills and strategies need improvement and where proficiency is already high enough	"You have to," "you had better" (controlling) "You can," "if you choose" (autonomy supportive) (Kanar & Bell, 2013)

Error management instructions. Error management instructions encourage trainees to make errors during training and to learn from them; errors are positively framed as learning opportunities. The goal of error management instructions is to turn learners' attention toward the informative aspect of errors and to reduce potential frustration. Most error management training interventions include such instructions to supplement exploration and experimentation. In initial studies, questions were asked such as “Why do you think you have made an error and what do you hypothesize to be the right procedure?” Participants were then encouraged to test their hypothesized solutions (Frese et al., 1988). Later studies provided written or orally presented statements during training such as “I have made an error, great because now I can learn something new!” (Frese et al., 1991) or “Errors are a natural part of learning. They point out what you can still learn!” (Dormann & Frese, 1994). In some applications, participants were informed about common errors prior to training (Gully et al., 2002).

Emotion control instructions. Emotion control involves “the use of self-regulatory processes to keep performance anxiety and other negative emotional reactions (e.g., worry) at bay during task engagement” (Kanfer, Ackerman, & Heggestad, 1996, p. 186). Error management instructions may be regarded as emotion control instructions because errors are framed positively. This positive view on errors may help trainees to reappraise errors as positive events and negative emotional reactions, thereby, may be reduced before they unfold (Keith & Frese, 2005). Other active learning interventions have used emotion control instructions without explicit reference to errors. For example, prior to each practice trial of a simulation, participants were instructed to increase the frequency of positive thoughts and to reduce the frequency of negative emotions (Kanfer & Ackerman, 1990). As another example, self-dialogue has been introduced to participants as a means to reduce frustration and anxiety. Learners were provided with statements such as “Remember, worry won’t help anything” and “This task may be challenging, but I know I CAN do it” or they were encouraged to create their own positive self-statements to control their emotions (Bell & Kozlowski, 2008).

Metacognitive instructions. Metacognition implies that an individual exerts self-regulatory “control over his or her cognitions” (Ford et al., 1998, p. 220) and it involves skills of planning and monitoring as well as evaluation of one’s progress during task completion (Brown, Bransford, Ferrara, & Campione, 1983). Instructions designed to increase metacognition during training may encourage participants to ask themselves questions such as “What is my Problem? What am I trying to achieve?” or “What do I know about the program so far that can be useful now?” (Keith & Frese, 2005). Metacognition may further be increased by instigating verbal self-explanation and communication with peers (Roll, Holmes, Day, & Bonn, 2012).

Adaptive guidance. Adaptive guidance provides learners with diagnostic and interpretive information enabling decisions where to direct one's effort. Based on a participant’s prior performance, the system adaptively suggests which skills and strategies still need improvement as well as where proficiency is already high so that the learner's attention can be directed accordingly (Bell & Kozlowski, 2002). Adaptive guidance goes beyond performance feedback and reminders about optimal strategies. It combines and supplements both by adaptively directing the learner’s attention to the most relevant learning topics with guidance tailored to the individual. Guiding instructions' framing may differ; instructions may be either coercive and controlling (“you have to,” “you had better”) or emphasize choice and self-initiated behaviors (“you can,” “if you choose”) (Kanar & Bell, 2013).

Effectiveness of active training: the evidence

The increasing popularity of active learning is often ascribed to characteristics of modern workplaces that are thought to call for active rather than more traditional learning forms (e.g., Bell & Kozlowski, 2008, 2010; Hesketh & Griffin, 2008; Keith & Frese, 2005, 2008). Modern workplaces are characterized by frequent changes, rapid cycles of technological development, uncertainty, and lower hierarchies. There is an increased necessity for continuous learning throughout one's working life, along with a shift of responsibility for one's career and personal development away from the organization to the employee him or herself (Hesketh & Griffin, 2008; Kraiger, 2003). The idea is that active learning approaches are most suitable—at least better than more traditional approaches—to deal with these workplace characteristics and necessities and, in general terms, to lead to better training outcomes. In the present section, we seek to provide an overview of empirical evidence concerning this claim. Apart from the general question whether active training works or not, we will deal with the question in what situations and for whom active training may be most promising or, conversely, in what situations more traditional guided and structured approaches may be preferred. It should be noted that, because there is no one single form of active learning, our conclusions cannot be generalized across all types of active learning. That being said, we believe that the currently available evidence does permit some theoretically and practically useful conclusions about the scope and boundaries of active training.

Studies evaluating the effectiveness of active training usually compare one (or more) active training conditions with either a no-training condition or with one (or more) alternative (e.g., proceduralized) training conditions. Studies using this evaluation design may yield significantly positive (i.e., in favor of the active training condition), negative (i.e., in favor of the alternative training condition or no-training condition), or non-significant effect sizes (i.e., no difference in effectiveness between training conditions). With regard to content domain of active-training interventions, several studies used computer-based decision- making simulations (e.g., Bell & Kozlowski, 2002, 2008; Ford et al., 1998; Gully et al., 2002; Kanar & Bell, 2013; Kozlowski & Bell, 2006; Kozlowski et al., 2001) or computer skills such as software training (e.g., Chillarege, Nordstrom, & Williams, 2003; Dormann & Frese, 1994; Frese et al., 1991; Heimbeck et al., 2003; Keith, Richter, & Naumann, 2010; Nordstrom, Wendland, & Williams, 1998) and electronic or web-based search tasks (e.g., Debowski, Wood, & Bandura, 2001; Lazar & Norcio, 2003; Wood et al., 2000). Other studies used management-related simulations of business administration (Ellington & Dierdorff, 2014), group management (Tabernero & Wood, 1999; Wood & Bandura, 1989), knowledge management (Leemkuil & de Jong, 2012), or production management (Goodman, Wood, & Chen, 2011). Other skills practiced in active-training interventions involved firefighting (Elliott et al., 2007; Joung, Hesketh, & Neal, 2006), a triage procedure (Van Dijk, 2010), hazard handling in a driving simulator (Ivancic & Hesketh, 2000; Wang, Zhang, & Salvendy, 2010), negotiation (Cullen et al., 2013; Gist, Bavetta, & Stevens, 1990; Gist, Stevens, & Bavetta, 1991; Stevens & Gist, 1997), and creative problem solving (Robledo et al., 2012). Finally, some studies used active training in a more academic context, for example, to teach mathematical models (Roll et al., 2012), physical phenomena (Olympiou, Zacharias, & de Jong, 2013), environmental phenomena (Barab et al., 2009), and principles of psychological experiments (Schwartz & Bransford, 1998). Recent studies that compared the effectiveness of active training interventions with non-active training comparison conditions are summarized in Table 6.3 (note that the table includes only studies that compared active training with non-active training; it does not include studies that compared different kinds of active-training conditions).

Table 6.3
Summary of the eight most recent studies on the effectiveness of active learning since Keith and Frese's (2008) meta-analysis

Study	N	M_{age}	Type	Training content	Active training condition	Experimental conditions	Main outcome	Effect size
Cullen et al. (2013)	132	24.2	RCT[a]	Negotiation skills	Learners reviewed transcripts of negotiations to identify the use of strategies and key behaviors. They also identified correct and incorrect behaviors following role plays.	(a) EMT; (b) BMT[e].	transfer performance after three weeks	No significant difference; r = .08, ns
Tsai (2011)	221	20	Field[b]	Build a website to establish a company		(a) SRL and CL+; (b) CL+; (c) CL-; (d) Traditional lecture.	Grades at the end of the course	(a) better than (b); t(119) = 3.44, p = .001; (b) better than (c); t(134) = 2.9, p = .004; (c) better than (d); MDIF = 13.3, SE = 1.75
van Dijk (2010)	49	21.2	RCT	Triage procedure		(a) Guided discovery; (b) Worked examples.	Total score (which comprised coherence of the mental model, knowledge retention, and knowledge application) of the delayed post-test after one week	No significant difference; U(23, 23) = 203, p = .18, (a) = 20.83, (b) = 26.17; higher ranks represent better scores
Wang et al. (2010)	32	23	RCT	Hazard handling in a driving simulator		(a) SET; (b) VGET.	Hazard handling on a full cockpit driving simulator after one week: errors and response distance	(a) made fewer errors than (b); t(30) = -2.29, p = .015 and the mean response distance was shorter for (a) than for (b); F(1, 30) = 6.76, p = .014; i.e., (a) reacted faster than (b)
Keith et al. (2010), Study 1	37	28.4	RCT	Software training (Microsoft Word)		(a) Active/exploratory; (b) Guided training.	Adaptive transfer	(a) better than (b); t(35) = 2.1, p < .05*, d = 0.69.
Keith et al. (2010), Study 2	110	24	RCT[c]	Software training (Microsoft PowerPoint)		(a) Active/exploratory; (b) Guided training.	Adaptive transfer	(a) better than (b); t(108) = 1.8, p < .05*, d = 0.34.
Carter & Beier (2010)	161	39.7	RCT	Software training (Microsoft Access)		(a) Low structure with error instructions; (b) high structure with error instructions; (c) high structure without error instructions.	Adaptive performance after one week	(a) better than (b) and (c); r = . 19, p < .05
Barab et al. (2009)	51	unde rgrad s	RCT[d]	Environmental phenomena (water quality, fish population)	In a virtual park (an aquatic habitat), participants explore what relations underlie the scenario (e.g., influence on how many fish there are) by exploration and experimentation (talk to virtual characters, conduct water analyses, serve as advisors)	(a) Single-user immersive world; (b) Immersive world; (c) Simplistic Framing; (d) Expository textbook.	Open-ended transfer task	(b) better than (c) and (d); F(1, 50) = 4.35, p = .01, η^2 = .16

For a subset of active training studies, namely those that used error management training (i.e., active/exploratory training with explicitly positive error management instructions), a meta-analysis is available that was published in 2008 (Keith & Frese, 2008). This meta-analysis included 24 studies that compared error management training with an alternative training condition (e.g., proceduralized step-by-step training, exploratory training without error encouragement). The mean effect size across all studies was 0.44 (Cohen's *d*) and statistically significant, indicating that on average error management training led to better training results than alternative training by 0.44 of a standard deviation. When considering only the more recent studies from Table 6.3 (i.e., studies that were not included in the 2008 meta-analysis), the mean effect size is significant and slightly larger at 0.68 (it remains significant, at 0.36, when the study by Tsai (2011) is treated as an outlier and removed from the study pool). There is, however, a considerable variation among effect sizes (range of −0.73 to larger than 1 in the 2008 meta-analysis) and a number of studies (both in the meta-analysis as well as in two of the studies depicted in the table) do not find any difference in training outcomes between training conditions. The conclusion that active training (or at least error management training as one example of active training) were generally effective and preferable compared to traditional training may therefore be premature. Rather, there may be moderators, that is, factors that relate to the magnitude of the effect size and that may condition the effectiveness of active training. In the following, we will highlight two such moderators that emerge in the literature and that have important implications for theory and practice of active learning (Keith, 2011, 2012; Keith & Frese, 2008). The first moderator refers to the distinction between immediate training performance and post-training transfer performance; the second moderator refers to the distinction between analogical transfer (i.e., transfer to tasks that are similar to training tasks) and adaptive transfer (i.e., transfer to tasks that are dissimilar from and more complex than training tasks).

Immediate training performance vs. post-training transfer performance

Active training cannot be expected to benefit immediate training performance; rather, it is directed at improving post-training transfer performance. An important but often neglected distinction in training evaluations is between immediate training performance (i.e., completion of training tasks) and post-training transfer performance (i.e., completion of tasks after training, in a transfer phase separate from training itself). This distinction is important because training interventions that benefit immediate training performance may not be effective in promoting transfer in the long run and, conversely, training interventions that may impede immediate training performance may still be effective in the long run (Bjork, 1994; Bjork & Bjork, 2011; Goodman & Wood, 2004; Hesketh, 1997; Keith & Frese, 2005, 2008; Schmidt & Bjork, 1992). A classical study from motor learning demonstrates this point (Shea & Morgan, 1979). In this study, participants learned several movements either in blocked practice or in randomized order. During training, participants of the blocked-practice condition outperformed those of the randomized-order condition but later in a transfer phase after training, the opposite pattern emerged: Randomized-order participants performed better, particularly if transfer tasks were also presented in a randomized order. The phenomenon that introducing difficulties during training may benefit learning and transfer in the long run has been demonstrated across a number of studies using different tasks and interventions, often subsumed under the concept of desirable difficulties. *Desirable difficulties* describe difficulties during learning that, provided learners respond to them successfully, lead to enhanced learning and retention (Bjork & Bjork, 2011). One example is the aforementioned benefit for learning and retention when training in randomized order rather than in blocked practice. Another example is the so-called testing effect

(Roediger & Karpicke, 2006), demonstrating that while initially repeated study of the same material may appear to lead to better retention, recall tests are a better method of study in the long run (i.e., worse recall after five minutes but better retention after one week).

The concept of desirable difficulties and the distinction between performance immediately during training vs. after training are relevant for active training for the following reason: Active training, in a way, induces a desirable difficulty, namely, active and independent exploration of the training tasks rather than detailed and guided instructions. The necessity to work independently and without much assistance during training makes the training more difficult for participants of active training. For participants of traditional training, in contrast, who receive guidance and instruction on how to solve the training tasks, no such difficulties arise. As a consequence, their immediate training performance may be better as they follow guiding instructions; long term learning and performance, however, may suffer (Hesketh, 1997; Ivancic & Hesketh, 1995/1996; Keith, 2005, 2008). In line with this argumentation, the meta-analysis on Error Management Training (Keith & Frese, 2008) found studies that used post-training transfer tasks to evaluate performance to yield larger mean effect sizes than those using training tasks (i.e., significant moderator effect). This finding has two implications for theory and practice of active learning. First, immediate training performance should not mistakenly be used to evaluate training effectiveness or to determine progress of training participants. Merely because participants correctly follow instructions (in guided step-by-step training) this does not mean that they really learned the procedures and will be able to use them outside the training situation. Conversely, merely because participants in training do not immediately find the correct solutions as they explore (in active training), this does not mean they were not learning about the training tasks. Second, motivating participants to actively explore and find solutions on their own may become a challenge for trainers. Some participants may simply reject working by themselves and not receiving guidance from the trainer. And even if participants do not entirely reject working independently, there may still be frustrating phases during training in which participants face difficulties and in which they would prefer to receive step-by-step guidance rather than being asked to find task solutions on their own.

Analogical vs. adaptive transfer

Active training may be more suitable to benefit adaptive than analogical transfer of training as compared to traditional guided training. Analogical transfer refers to situations in which transfer tasks are similar to training tasks; analogical transfer tasks can be solved with procedures analogous to those learned during training (Ivancic & Hesketh, 2000). Adaptive transfer, in contrast, implies that new solutions need to be developed to solve the tasks and that procedures be used that have not been taught during training (Ivancic & Hesketh, 2000; a similar distinction is that of near and far transfer, e.g., Barnett & Ceci, 2002). Training programs may differ as to whether the focus is on analogical or on adaptive transfer. If, for example, the training goal is to learn a clearly definable procedure or set of procedures (i.e., analogical transfer), it makes sense to teach these procedures directly using step-by-step guidance. Using active training in this situation, that is, encouraging trainees to find out about the correct procedures by exploration, may or may not lead to the goal as well, but it certainly is more time consuming than direct instruction. A different situation arises when during training not all work-related problems and their solutions can be taught and in which, therefore, the training goal is to enable training participants to independently develop solutions to new problems at work (i.e., adaptive transfer). In this case, active training methods may be particularly suitable as they resemble the transfer situation more than guided step-by-step training. While during training there may be a trainer present who can help with the tasks at hand, back at work in the transfer situation the trainee needs to be able to develop solutions without a trainer. In a way, active training is a more realistic representation of the transfer situation than guided training. Trainees of active training may be better prepared to deal with difficulties in the transfer situation because they already learned during training to explore the tasks and to find solutions independently. Also, provided participants made the positive experience during training that they are able to deal with problems without much assistance, they may be more confident and subsequently be more persistent in the transfer situation. This issue is also known as the principle of transfer appropriate processing, which postulates that those processes required on transfer tasks should be practiced in training (Morris, Bransford, & Franks, 1977).

In line with this reasoning, the meta-analysis on error management training found type of transfer task to moderate training effectiveness. Although for studies using analogical transfer tasks to evaluate training effectiveness a significant mean effect size was found, the magnitude of the effect was small (Cohen's $d = 0.20$). For studies using adaptive transfer tasks, however, the effect size was significantly larger and of large magnitude (Cohen's $d = 0.80$), implying that active training may be particularly beneficial for adaptive transfer tasks. For the practice of active training, this implies that trainers may, before choosing between active training and more guided training methods, consider the particular training goal, that is, whether analogical or adaptive transfer is required back on the job (Hesketh, 1997; Keith, 2011, 2012; Keith & Frese, 2005, 2008; Kozlowski et al., 2001).

Mechanisms of active training: What do we know about why it works?

The previous section dealt with the general question asking whether active training is effective and, additionally, in what situations it may be more beneficial than in others. While the answers to this question already have implications for the application of active training, the present section goes one step further by dealing with the mechanisms and psychological processes that underlie the effectiveness of active training. Identifying the processes both deepens our theoretical understanding of active training and opens up the possibility to design more specific training interventions that purposely address these very processes.

The basic assumption of active learning theory is that the activity of training participants instigates particular processes that benefit learning; it further assumed that these processes are not or only to a lesser extent instigated in participants of non-active, more traditional training. These processes are then thought to function as mechanisms that explain the effectiveness of active training. But what kind of processes may that be? In the following, we will review a number of processes that have been proposed in the literature as possible pathways of training effectiveness. Where available, we will also describe empirical evidence concerning these processes. These proposed processes may be grouped according to their emphasis either on cognitive, emotional, or motivational processes that may be instigated in active training. Another approach attempts to integrate these views using a self-regulatory perspective. The next paragraphs will be organized along these lines. Where applicable, we will also refer back to the previously described basic dimensions and supplemental components of active training.

Cognitive processes in active training

As outlined above, a basic dimension of active training is active exploration and experimentation during training. In addition, active training approaches, in contrast to traditional guided training methods, tend to provide trainees with only little task information. As a consequence, much of the knowledge and skills required for successful task completion needs to be developed by participants themselves as they explore the training tasks. In doing so, participants will inevitably make errors and some active training approaches, most notably error management training, explicitly encourage making errors during training and learning from them. All of these elements of active training may contribute to learning. The active involvement of trainees and the requirement to develop knowledge and skills during independent exploration may lead to deeper cognitive processing of task-related information than under conditions of more passive instruction (Bell & Kozlowski, 2008, 2010; Heimbeck et al., 2003; Keith & Frese, 2005; Ivancic & Hesketh, 1995/1996). As participants explore the training tasks, their attention is constantly triggered; they constantly need to reflect on what they are doing and whether their task strategies are successful or need to be changed (Keith, 2011, 2012; Keith & Frese, 2005, 2008). While participants of traditional, more passive forms of instruction may also opt to be attentive and reflective during training, expending this cognitive effort is probably not as essential for task completion as it is in active training. This proposition is in line with action theory (Frese & Zapf, 1994; Hacker, 1973) which posits that active exploration of task solutions may lead to more adequate and richer mental models of the subject under study than more passive forms of instruction. In fact, Dormann and Frese (1994) found the extent of exploration during training to be related to post-training performance on a transfer task. Bell and Kozlowski (2008), who systematically varied several training design elements found exploration during training, as compared to step-by-step guidance, to benefit performance.

Making errors has been proposed to instigate learning (e.g., Frese et al., 1991; Ivancic & Hesketh, 1995/1996, 2000; Heimbeck et al., 2003; Keith & Frese, 2005). Errors may improve mental models of the training subject because they pinpoint incorrect assumptions and motivate participants to correct these erroneous assumptions (Keith, 2011, 2012). In line with this proposition, error-related events have been found to be associated with richer mental models than successful ones (Ellis & Davidi, 2005). Errors may also attract attention because they disrupt task completion and participants may then devote their attention to understanding the error and its cause and to finding a solution to the problem (Ivancic & Hesketh, 1995/1996, 2000). The literature on error management training (a method of active training which, as described above in section 3, combines active exploration with explicit error encouragement) suggests that errors are effective in promoting learning and transfer. In particular, the meta-analysis of 24 studies of error management training found a positive and significant mean effect size in favor of error management training. It should be noted, however, that exploration and making errors are inherently confounded in active training. It is therefore difficult to empirically disentangle the effects of errors and of exploration (cf. Bell & Kozlowski, 2008; Gully et al., 2002).

Motivational processes in active training

Active training may be more motivating for trainees than traditional proceduralized training as they are allowed to work at their own pace and explore tasks on their own rather than following instructions by an external agent (i.e., the trainer). Active training may increase self-determination (Deci & Ryan, 1985) as participants enjoy actively exploring the tasks and decide to spend more effort, which in turn may benefit learning. Instructions to increase mastery or learning goal orientation, which are employed in some active training applications also target participants' motivation during training. The empirical evidence concerning motivation in active training is mixed. For example, a study by Wood et al. (2000) expected intrinsic motivation to mediate effects of enactive exploration (i.e., an active training intervention) in an electronic search task. Contrary to expectations, however, intrinsic motivation was unrelated to performance.

Emotional processes in active training. As mentioned above, active exploration and making errors may at times become frustrating for trainees. To reduce frustration in exploratory training, Frese et al. 1991 introduced so-called error management instructions that aimed at reducing frustration for trainees (e.g., "Say to yourself: I have made an error, great, because now I can learn something new"). It is plausible to assume that these instructions alleviate negative emotions such as anger and frustration during training—emotions that would otherwise distract from the task at hand which in turn would impede learning (Kanfer & Ackerman, 1989). Also, while working on difficult tasks in a later transfer phase, trainees who have previously received error management instructions may be better equipped to deal with potential negative emotions in the face of errors and setbacks. In line with this reasoning, various instructions of error encouragement (i.e., error management instructions or similar ones) appear to be an effective element of error management training (Bell & Kozlowski, 2008; Heimbeck et al., 2003; Keith & Frese, 2008). Results of studies that directly assessed negative emotions, however, yielded inconsistent results. For example, Nordstrom et al. (1998) compared levels of frustration in participants of error management training to that in participants of a traditional proceduralized training method. As expected, frustration decreased in the former and increased in the latter. This effect, however, was not replicated in a similar study (Chillarege et al., 2003).

Self-regulation of cognitions and emotions in active training

The previous sections have separately considered cognitive, motivational, and emotional processes that may account for the effectiveness of active training. More probably than not, no one single but several mechanisms together account for the effectiveness of active training. In an attempt to integrate emotional and cognitive perspectives, Keith and Frese (2005) introduced a self-regulatory framework that stresses both emotional and cognitive paths to explain the effectiveness of error management training (for a similar approach, see Bell & Kozlowski, 2008). Self-regulation involves processes "that enable an individual to guide his or her goal-directed activities over time" (Karoly, 1993, p. 25) and serves to reduce discrepancies between goals and performance (Sitzmann & Ely, 2010). Self-regulation may particularly be important for participants in error management training because they work independently and do not receive much guidance during training (cf. Bell & Kozlowksi, 2008; Ford et al., 1998). These self-regulatory skills that participants exert during training may in turn be useful when participants are later confronted with novel tasks that were not introduced during training (i.e., adaptive transfer). Self-regulation can be directed at the "modulation of thought, affect, behavior, or attention" (Karoly, 1993, p. 25).

The two self-regulatory skills investigated by Keith and Frese (2005) were emotion control (i.e., self-regulation of emotions or affect) and metacognition (i.e., self-regulation of cognitions). *Emotion control* is aimed at reducing negative emotional reactions to setbacks and errors (Kanfer, Ackerman, & Heggestad, 1996). Error management training may encourage emotion control through positive framing of errors in error management instructions. *Metacognition* includes planning, monitoring, evaluation, and revision of task strategies during task completion (Brown, Bransford, Ferrara, & Campione, 1983). Error management training may be conducive to the development of such skills because "errors prompt learners to stop and think about the causes of the error" (Ivancic & Hesketh, 2000, p. 1968), to come up with potential solutions to the problem, and to implement and test them. In short, Keith and Frese (2005) expected emotion control and metacognitive activities to be stimulated in error management training but not or to a lesser extent in conventional guided training. They further expected these two self-regulatory skills to benefit performance on adaptive transfer tasks and to explain effectiveness of error management training. In line with expectations, emotion control and metacognitive activity during training fully and independently mediated the effect of training method (i.e., error management vs. conventional guided training) on adaptive transfer performance. These results highlight the importance of both emotional and cognitive processes for the effectiveness of error management training (as one particular active training method) and probably for active training in general. They are also in line with the principle of transfer appropriate processing (Morris et al., 1977) mentioned above (cf. section 4) which states that processes that are needed during transfer should be practiced during training. It appears that participants of active training learn to exert self-regulatory skills of emotion control and metacognition during training as they work independently on tasks—skills that prove useful when confronted with novel adaptive transfer tasks that need to be solved without external guidance by a trainer (cf. Keith 2011, 2012).

Evidence on aptitude-treatment interactions (ATI): Who benefits most from active training?

The previous sections dealt with the effectiveness of active training and potential mediating mechanisms in general, that is, without consideration of trainee characteristics. It is a common assumption, however, that not all trainees benefit equally from the same training method (Gully & Chen, 2010)—in the present case, from active training. This issue has been termed aptitude-treatment interaction (ATI; Cronbach & Snow, 1977), with 'treatment' representing the training method (i.e., active training vs. alternative training) and with 'aptitude' encompassing various person aptitudes or attributes such as cognitive abilities, interests, motivation, and personality. Indeed, the many recent studies on active training do not focus on main effects of active training but follow the idea of ATI and specifically address potential interactions of training condition with various person characteristics. In many cases, the idea is to test who benefits most (or least) from active training, that is, to examine what training method is favorable depending on person characteristics of the trainee. A second approach to ATIs is not to look at levels of person characteristics (e.g., high or low cognitive ability) but on differential effects of them on training outcomes. For example, it is possible that some person characteristic (e.g., cognitive ability) affects training outcomes only for trainees of active learning but not for trainees of structured training or vice versa. In the following, we will refer to and attempt to integrate results of research of both perspectives. It should be noted, however, that integrating results of ATI research to a coherent picture is a difficult task. This is because, first, statistical interactions or moderations (in the present case, between training condition and person attributes) are generally more difficult to detect and to replicate and at times results concerning the same person attributes are contradictory. Second, research on active training has only begun to systematically investigate ATIs and the presently available evidence is based on quite heterogeneous task domains, treatments (e.g., active/ exploratory with or without error encouragement), comparison training conditions (e.g., different active training conditions or active vs. structured training), and dependent variables. We have also opted to omit, for the sake of clarity of presentation, even more complex findings such as three-way interactions (Carter & Beier, 2010) and interactions on mediating variables (Bell & Kozlowski, 2008). The following overview is organized around potential moderators, namely, cognitive ability, motivation, and personality. Where applicable, we will consider different dimensions and components of active training (e.g., exploration and error encouragement;) separately.

Cognitive Ability

Exploration. The effect of cognitive ability appears to be reduced in active training as compared to proceduralized training. In terms of levels of cognitive ability, research indicates that for high ability trainees, the training method (i.e., active vs. proceduralized training) does not matter for performance whereas for low ability trainees, active training is preferable to proceduralized training (Keith et al., 2010). This effect may be explained in terms of resource allocation theory (Kanfer & Ackerman, 1989); the idea is that cognitive resources may be more crucial in less engaging training environments (Keith et al., 2010). Note that this finding may be counterintuitive; often it is argued that exploration in active training poses demands on learners that are better met in high-ability trainees (Gully et al., 2002) whereas these findings indicate active training to be beneficial for trainees of all levels of cognitive ability.

Error encouragement. With regard to error encouragement, it appears that encouraging errors is particularly effective for individuals with higher, rather than lower, ability. Making errors and dealing with them probably costs cognitive/attentional resources. Encouraging errors may therefore be counterproductive for individuals with lower cognitive ability. In line with this proposition, two studies found higher-ability individuals to benefit more from error encouragement than individuals with lower ability (Gully et al., 2002; Loh et al., 2013). In both studies, the comparison conditions were exploratory training with neutral or with avoidant error instructions.

Motivation

Exploratory training as compared to proceduralized training appears to reduce the role of motivation in training effectiveness. The pattern is the same as for cognitive ability: While for highly motivated trainees, training conditions did not matter, performance of trainees with low motivation was worse in structured training. Again, this pattern may be explained with reference to resource allocation theory as motivation plays a role in allocation of attentional resources during task completion (Kanfer & Ackerman, 1989). Another study found that during guided exploration, the influence of motivation on performance growth was reduced but only when guiding instructions were phrased in a controlling rather than autonomy-supportive way (Kanar & Bell, 2013). A similar result was found for the construct of goal orientation; while in proceduralized training low performance goal orientation (i.e., prove and avoidance orientation) was detrimental to performance, in active training this motivational person characteristic did not affect performance (Heimbeck et al., 2003). In other words, active training was beneficial for trainees of all levels of motivation.

Personality

Openness to experience and agreeableness. Individuals characterized as more open to experience may be expected to be more willing to make mistakes and to learn from them. Results supported this view in that error encouragement instructions were more beneficial than error avoidance instructions for individuals higher in openness to experience (Gully et al., 2002; Loh et al., 2013). Similar results were found with respect to agreeableness (Loh et al., 2013). Individuals lower in openness to experience either performed worse (Gully et al., 2002) or no differences between conditions were found (Loh et al., 2013).

Conscientiousness. Highly conscientious learners are self-disciplined and effortful in their approach to learning which may lead to the prediction that they benefit from active training. In line with this prediction, in one study they benefited more form error management training than from a guided training method (Cullen et al., 2013). On the other hand, one particular facet of conscientiousness—cautiousness—involves a tendency to avoid mistakes. Cautiousness may explain why in one study error encouragement reduced self-efficacy in individuals with higher levels of conscientiousness (Gully et al., 2002).

Extraversion. Extraversion may be expected to match active learning as compared to a more guided behavioral modeling approach because extraverts prefer being actively involved rather than being required to passively receive information. In line with this assumption, one study showed that extraverted learners benefited more from error management training whereas introverted trainees benefited more from behavioral modeling training (Cullen et al., 2013).

Challenges to the concept of active learning

The present chapter has been rather optimistic about active learning. Yet, active learning principles or, more generally speaking, constructivist approaches to learning have not gone uncriticized (e.g., Mayer, 2004). In particular, proponents of cognitive load theory argue that unstructured and discovery-based training methods may increase what is called extraneous load, that is, cognitive load that does not benefit learning but that poses additional demands on the learner and should be reduced. Indeed, in the context of cognitive load theory, a number of studies and meta-analytical findings indicate that guidance (e.g., worked-out examples of problems) are better for learning than discovery-based methods (e.g., Kirschner, Sweller, & Clark, 2006). We suggest that this apparent contradiction—that active training benefits learning in one set of studies and is detrimental in the other—may be resolved with reference to the type of transfer or respective training goal involved in the studies (cf. section 4): While active training is particularly effective for adaptive transfer tasks, many of the studies using guided approaches within the framework of cognitive load theory probably use analogical transfer task in which a specific principle taught in training needs to be applied to a similar problem. Another obvious difference between the literature on cognitive load theory and the presently reviewed active-training studies is the sample and setting; while the former focuses on students in school settings, the present chapter only considered studies using adult samples. In any case, a challenge to theory and practice of active training is that the desirable difficulties (Bjork, 1994) induced by active training do not become undesirable difficulties for the learner, that is, pose additional demands on the learners that he or she is not equipped to master. The findings regarding ATIs (section6) may be informative in deciding what learners may or may not benefit from active training. It should be noted, however, that at least some of the available studies point out to a seemingly counterintuitive finding (at least not in line with cognitive load theory), namely, that all learners, regardless of their cognitive ability and motivation, benefit from active training while guided training is detrimental to learners of lower ability and lower motivation (Heimbeck et al., 2003; Keith et al., 2010). These finding may be explained with reference to the resource allocation theory by Kanfer and Ackerman (1989) but this explanation is somewhat speculative at this point (cf. Keith et al., 2010). Future research may investigate in more detail whether this explanation holds and attempt to solve the contradiction between the literatures on cognitive load theory and the presently reviewed active training studies.

We have suggested exploration in active training to represent a desirable difficulty that may impede immediate training performance but that is beneficial in the long run (cf. section 4). An interesting phenomenon in the context of desirable difficulties is that learners often mistake apparent initial learning with actual learning and retention. That is, learners tend to prefer learning strategies that increase apparent learning (e.g., massed practice, repeated study) over strategies that increase actual learning and retention but that may initially slow the learning rate (e.g., distributed practice, testing of studied material) (Kornell & Bjork, 2008). With regard to active training, some trainees may be reluctant to go through the effort of independent exploration when a trainer is available who, in principle, could guide them to correct task solutions. During exploration, trainees may subjectively perceive learning to be less effective and more demanding—and thereby less motivating—than traditional approaches. Likewise, trainers may also be inclined to use more structured training methods that increase apparent learning rather than have trainees struggle to correct task solutions on their own. It may be a challenge for both trainers and trainees to find a balance between the desire for guidance and more effortful but probably more beneficial active exploration.

Future research

Many of the studies presented in this chapter used active training to train technical skills (e.g., computer skills) or at least computer-based tasks (e.g., computer-delivered decision-making tasks), although more recent studies have applied active training to a diverse set of skills. Also, many of the outcome variables assessed to evaluate training effectiveness were skill-based measures and actual on-the-job performance after training has rarely been assessed. Future research may continue to investigate generalizability of findings to diverse skills and settings and to systematically relate effects of active training to a taxonomy of analogical and adaptive transfer tasks in closed skills (i.e., skills that require the execution of particular procedures) and open skills (i.e., skills that leave latitude in deciding a course of action; cf. Blume, Ford, Baldwin, & Huang, 2010). In addition, this chapter has primarily focused on active *training* (as opposed to active *learning* in general), with the most notable characteristic of exploration as opposed to structure and guidance during training. Yet, as mentioned in the beginning of this chapter, many other approaches (e.g., cooperative learning in groups) may be conceived of as active learning approaches. Future research may systematically analyze similarities and differences in diverse active learning approaches, their underlying mechanisms, and interactions with interindividual difference variables. In this context, investigating informal active learning in organizations may be of particular interest given that much of the learning that takes place in organizations appears to be informal (Kraiger, 2003; Tannenbaum et al., 2010). Indeed, research has shown that so-called deliberate practice activities, that is, self-regulated practice activities at work with the explicit goal of performance improvement, predicts performance (Keith & Ericsson, 2007; Sonnentag & Kleine, 2000; Unger, Keith, Hilling, Gielnik, & Frese, 2009). Future research may investigate what characteristics of persons and of the work environment (e.g., job characteristics, organizational culture) are conducive to such active learning of employees at work—along with potential costs associated with learners' effort that is inherent in active learning.

Conclusion

Active learning implies that learners assigned an active role in the learning process; the responsibility for learning is shifted from external agents (i.e., the trainers or teachers) to the learners themselves. The present chapter gave a brief overview of active learning approaches in different settings (e.g., informal active learning at work vs. within formalized training; individual learning vs. learning in groups) and then focused on one subset of active learning approaches, namely, active training which emphasizes exploration and experimentation during training. Research indicates that active training is beneficial as compared to traditional guided approaches particularly when transfer to novel and complex problems (i.e., adaptive transfer) is the training objective. For transfer to problems that are similar to those taught during training and that need to be performed in some prescribed manner (i.e., analogical transfer), active training might work as well, but guided and structured approaches which directly teach the required skill are probably more efficient. Trainers may therefore consider the training objective before deciding on whether to use active training or more guided training methods. Also, trainee characteristics such as cognitive ability or personality of trainees may be considered, although the current evidence suggest that active exploration is beneficial for trainees of all levels of cognitive abilities and motivation. Active training interventions have been conducted in content domains or used tasks such as decision-making, computer skills, management skill simulations, and more specific job-related skills such as firefighting. While it is our hope that this interest of researchers and practitioners in active learning interventions continues, a major challenge may be to design active training such that the desirable difficulties induced in training do not turn into undesirables ones that may impede learning or motivation of trainees.

References

Aronson, E., & Bridgeman, D. (1979). Jigsaw groups and the desegregated classroom: In pursuit of common goals. *Personality and Social Psychology Bulletin, 5*, 438-446.

Barab, S. A., Scott, B., Siyahhan, S., Goldstone, R., Ingram-Goble, A., Zuiker, S. J., & Warren, S. (2009). Transformational Play as a Curricular Scaffold: Using Videogames to Support Science Education. *Journal of Science Education and Technology*, *18*, 305–320. doi:10.1007/s10956-009-9171-5

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin, 128*, 612-637.

Bell, B. S., & Kozlowski, S. W. J. (2002). Adaptive guidance: Enhancing self-regulation, knowledge, and performance in technology-based training. *Personnel Psychology*, *55*, 267–306.

Bell, B. S., & Kozlowski, S. W. J. (2008). Active learning: Effects of core training design elements on self-regulatory processes, learning, and adaptability. *Journal of Applied Psychology*, *93*, 296–316.

Bell, B. S., & Kozlowski, S. W. J. (2010). Toward a theory of learner-centered training design: An integrative framework of active learning. In S. W. J. Kozlowski & E. Salas (eds.), *Learning, training, and development in organizations* (pp. 263-300). New York: Taylor and Francis.

Bjork, R.A. (1994). Memory and metamemory considerations in the training of human beings. In J. Metcalfe & A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 185-205). Cambridge, MA: MIT Press.

Bjork, E. L., & Bjork, R. A. (2011). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In M. A. Gernsbacher, R. W. Pew, L M. Hough, & J. R. Pomerantz (eds.). *Psychology and the real world: Essays illustrating fundamental contributions to society* (pp. 56-64). New York, NY, US: Worth Publishers.

Blume, B. D., Ford, J. K., Baldwin, T. T., & Huang, J. L. (2010). Transfer of training: A meta-analytic review. *Journal of Management, 36*, 1065-1106.

Brown, A. L., Bransford, J. D., Ferrara, R. A., & Campione, J. C. (1983). Learning, remembering, and understanding. In J. H. Flavell & E. M. Markman (Eds.), *Handbook of child psychology* (Vol. 3, pp. 77-166). New York: Wiley.

Bruner, J. S. (1966). *Toward a theory of instruction*. Cambridge, MA: Harvard University Press.

Carter, M., & Beier, M. E. (2010). The effectiveness of error management training with working-aged adults. *Personnel Psychology*, *63*(3), 641-675. doi:10.1111/j.1744-6570.2010.01183.x

Chillarege, K. A., Nordstrom, C. R., & Williams, K. B. (2003). Learning from our mistakes: Error management training for mature learners. *Journal of Business and Psychology, 17*, 369-385.

Cronbach, L. J., & Snow, R. E. (1977). *Aptitudes and instructional methods: A handbook for research on interactions*. New York: Irvington.

Cullen, M. J., Muros, J. P., Rasch, R., & Sackett, P. R. (2013). Individual differences in the effectiveness of error management training for developing negotiation skills. *International Journal of Selection and Assessment*, *21*(1), 1-21. doi:10.1111/ijsa.12013

Daniels, K.J., Boocock, J.G., Glover, J., Hartley, R. and Holland, J. (2009) An experience sampling study of learning, affect, and the demands control support model. *Journal of Applied Psychology, 94*, 1003-1017.

Debowski, S., Wood, R. E., & Bandura, A. (2001). Impact of guided exploration on self-regulatory mechanisms and information acquisition through electronic search. *Journal of Applied Psychology, 86*, 1129-1141.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum.

Dormann, T., & Frese, M. (1994). Error management training: Replication and the function of exploratory behavior. *International Journal of Human-Computer Interaction, 6*, 365-372.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23*, 5-12.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*, 256-273.

Elliott, T., Welsh, M., Nettelbeck, T., & Mills, V. (2007). Investigating naturalistic decision making in a simulated microworld: What questions should we ask?. *Behavior Research Methods*, *39*, 901–910.

Ellis, S., & Davidi, I. (2005). After-event reviews: Drawing lessons from successful and failed experience. *Journal of Applied Psychology, 90,* 857-871.

Ford, J. K., Smith, E. M., Weissbein, D. A., Gully, S. M., & Salas, E. (1998). Relationships of goal orientation, metacognitive activity, and practice strategies with learning outcomes and transfer. *Journal of Applied Psychology, 83*, 218-233.

Frese, M., Albrecht, K., Altmann, A., Lang, J., Papstein, P. V., Peyerl, R., Prümper, J., et al. (1988). The effects of an active development of the mental model in the training process: Experimental results in a word processing system. *Behaviour & Information Technology*, *7*, 295–304.

Frese, M., Brodbeck, F. C., Heinbokel, T., Mooser, C., Schleiffenbaum, E., & Thiemann, P. (1991). Errors in training computer skills: On the positive function of errors. *Human-Computer Interaction, 6*, 77-93.

Frese, M., & Zapf, D. (1994). Action as the core of work psychology: A German approach. In H. C. Triandis, M. D. Dunette, & L. M. Hough (Eds.), *Handbook of industrial and organizational psychology* (Vol. 4, pp. 271-340). Palo Alto, CA: Consulting Psychologists Press.

Gist, M. E., Bavetta, A. G., & Stevens, C. K. (1990). Transfer training method: Its influence on skill generalization, skill repetition, and performance level. *Personnel Psychology*, *43*, 501–523.

Gist, M. E., Stevens, C. K., & Bavetta, A. G. (1991). Effects of self-efficacy and post-training intervention on the acquisition and maintenance of complex interpersonal skills. *Personnel Psychology*, *44*, 837–861.

Goodman, J., & Wood, R. E. (2004). Feedback specificity, learning opportunities, and learning. *Journal of Applied Psychology, 89*, 809-821.

Goodman, J. S., Wood, R. E., & Chen, Z. (2011). Feedback specificity, information processing, and transfer of training. *Organizational Behavior and Human Decision Processes*, *115*(2), 253-267. doi:10.1016/j.obhdp.2011.01.001

Gully, S. M., & Chen, G. (2010). Individual differences, attribute-treatment interactions, and training outcomes. In S. W. J. Kozlowski & E. Salas (eds.), *Learning, training, and development in organizations* (pp. 3-64). New York: Taylor and Francis.

Gully, S. M., Payne, S. C., Koles, K. L. K., & Whiteman, J. A. K. (2002). The impact of error management training and individual differences on training outcomes: An attribute-treatment interaction perspective. *Journal of Applied Psychology, 87*, 143-155.

Hacker, W. (1973). Allgemeine Arbeits- und Ingenieurspsychologie [General work and engineering psychology]. Berlin (Germany): VEB Deutscher Verlag der Wissenschaften.

Heimbeck, D., Frese, M., Sonnentag, S., & Keith, N. (2003). Integrating errors into the training process: The function of error management instructions and the role of goal orientation. *Personnel Psychology, 56*, 333-361.

Hesketh, B. (1997). Dilemmas in training for transfer and retention. *Applied Psychology: An International Review, 46*, 317-339.

Hesketh, B., & Griffin, B. (2008). Selection and training for work adjustment and adaptability. In C. Cooper & S. Cartwright (Eds.). *The Oxford Handbook of Personnel Psychology* (pp. 366-387). New York: Oxford University Press.

Hsu, Y.-C., & Ching, Y.-H. (2013). Mobile computer-supported collaborative learning: A review of experimental research. *British Journal of Educational Technology, 44*, E111–E114.

Ivancic, K., & Hesketh, B. (1995/1996). Making the best of errors during training. *Training Research Journal, 1*, 103-125.

Ivancic, K., & Hesketh, B. (2000). Learning from error in a driving simulation: Effects on driving skill and self-confidence. *Ergonomics, 43*, 1966-1984.

Joung, W., Hesketh, B., & Neal, A. (2006). Using "War Stories" to Train for Adaptive Performance: Is it Better to Learn from Error or Success?. *Applied Psychology: An International Review, 55*, 282-302.

Kamouri, A. L., Kamouri, J., & Smith, K. H. (1986). Training by exploration: Facilitating the transfer of procedural knowledge through analogical reasoning. *International Journal of Man-Machine Studies*, *24*, 171–192.

Kanar, A. M., & Bell, B. S. (2013). Guiding learners through technology-based instruction: The effects of adaptive guidance design and individual differences on learning over time. *Journal of Educational Psychology*, *105*, 1067–1081.

Kanfer, R. & Ackerman, P. L. (1989). Motivation and cognitive abilities: An integrative/aptitude-treatment interaction approach to skill acquisition [Monograph]. *Journal of Applied Psychology, 74*, 657-690.

Kanfer, R., & Ackerman, P. L. (1990). Ability and metacognitive determinants of skill acquisition and transfer (Air Force Office of Scientific Research Final Report). Minneapolis, MN: Air Force Office of Scientific Research.

Kanfer, R., Ackerman, P. L., & Heggestad, E. D. (1996). Motivational skills and self-regulation for learning: A trait perspective. *Learning and Individual Differences, 8*, 185-209.

Karasek, R. A., & Theorell, T. (1990). *Healthy work*. New York: Basic Books.

Karoly, P. (1993). Mechanisms of self-regulation: A systems view. *Annual Review of Psychology, 44*, 23-52.

Keith, N. (2011). Learning through errors in training. In D. Hofmann & M. Frese (Eds.), *Errors in organizations* (pp. 45-65). New York: Taylor & Francis.

Keith, N. (2012). Managing errors during training. In J. Bauer & C. Harteis (Eds.), *Human fallibility: The ambiguity of errors for work and learning* (pp. 173-196). New York: Springer.

Keith, N., & Ericsson, K. A. (2007). A deliberate practice account of typing proficiency in everyday typists. *Journal of Experimental Psychology: Applied, 13*, 135-145.

Keith, N., & Frese, M. (2005). Self-regulation in error management training: Emotion control and metacognition as mediators of performance effects. *Journal of Applied Psychology, 90*, 677-691.

Keith, N., & Frese, M. (2008). Effectiveness of error management training: A meta-analysis. *Journal of Applied Psychology, 93*, 59-69.

Keith, N., Richter, T., & Naumann, J. (2010). Active/exploratory training promotes transfer even in learners with low motivation and cognitive ability. *Applied Psychology: An International Review, 59*, 97-123.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*, 75-86.

Kornell, N., & Bjork, R. A. (2007). The promise and perils of self-regulated study. *Psychonomic Bulletin & Review, 14*, 219–224.

Kozlowski, S. W. J., & Bell, B. S. (2006). Disentangling achievement orientation and goal setting: Effects on self-regulatory processes. *Journal of Applied Psychology*, *91*, 900–916.

Kozlowski, S. W. J., Gully, S. M., Brown, K. G., Salas, E., Smith, E. M., & Nason, E. R. (2001). Effects of training goals and goal orientation traits on multidimensional training outcomes and performance adaptability. *Organizational Behavior and Human Decision Processes*, *85*, 1–31.

Kraiger, K. (2003). Perspectives on training and development. In W. C. Borman, D. R. Ilgen, & R. J. Klimoski (eds.). *Handbook of psychology: Industrial and organizational psychology, Vol. 12.* (pp. 171-192). Hoboken, NJ, US: John Wiley & Sons Inc.

Kraiger, K., & Jerden, E. (2007). A meta-analytic investigation of learner control: Old findings and new directions. In S. M. Fiore, & E. Salas (Eds.), *Toward a science of distributed learning* (pp. 65-90). Washington, DC, US: American Psychological Association.

Lazar, J., & Norcio, A. (2003). Training novice users in developing strategies for responding to errors when browsing the web. *International Journal of Human-Computer Interaction, 15*, 361-377.

Leemkuil, H., & de Jong, T. (2012). Adaptive advice in learning with a computer-based knowledge management simulation game. *Academy of Management Learning & Education*, *11*, 653–665.

Loh, V., Andrews, S., Hesketh, B., & Griffin, B. (2013). The moderating effect of individual differences in error-management training: Who learns from mistakes?. *Human Factors*, *55*, 435–448.

Martocchio, J. J. (1994). Effects of conceptions of ability on anxiety, self-efficacy, and learning in training. *Journal of Applied Psychology*, *79*, 819–825.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist*, *59*, 1–14.

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior, 16*, 519-533.

Nordstrom, C. R., Wendland, D., & Williams, K. B. (1998). "To err is human": An examination of the effectiveness of error management training. *Journal of Business and Psychology, 12*, 269-282.

Olympiou, G., Zacharias, Z., & deJong, T. (2013). Making the invisible visible: Enhancing students' conceptual understanding by introducing representations of abstract objects in a simulation. *Instructional Science*, *41*, 575–596.

Robledo, I. C., Hester, K. S., Peterson, D. R., Barrett, J. D., Day, E. A., Hougen, D. P., & Mumford, M. D. (2012). Errors and Understanding: The Effects of Error-Management Training on Creative Problem-Solving. *Creativity Research Journal*, *24*, 220–234. doi: 10.1080/10400419.2012.677352

Roediger, H.L. & Karpicke, J.D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science, 17*, 249-255.

Roll, I., Holmes, N. G., Day, J., & Bonn, D. (2012). Evaluating metacognitive scaffolding in guided invention activities. *Instructional Science*, *40*, 691–710.

Schmidt, R. A., & Bjork, R. A. (1992). New conceptualizations of practice: Common principles in three paradigms suggest new concepts for training. *Psychological Science, 3*, 207-217.

Schwartz, D. L., & Bransford, J. D. (1998). A Time For Telling. *Cognition and Instruction*, *16*, 475–5223. doi:10.1207/s1532690xci1604_4

Shea, J. B., & Morgan, R. L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor skill. *Journal of Experimental Psychology: Human Learning and Memory, 5*, 179-187.

Sitzmann, T., & Ely, K. (2010). Sometimes you need a reminder: The effects of prompting self-regulation on regulatory processes, learning, and attrition. *Journal of Applied Psychology, 95*, 132–144.

Sonnentag, S., & Kleine, B. M. (2000). Deliberate practice at work: A study with insurance agents. *Journal of Occupational and Organizational Psychology, 73*, 87-102.

Sonnentag, S., Niessen, C., & Ohly, S. (2004). Learning at work: Training and development. In C. L. Cooper & I. T. Robertson (Eds.), *International review of industrial and organizational psychology* (Vol. 19, pp. 249-289). Chichester: Wiley.

Stevens, C. K., & Gist, M. E. (1997). Effects of self-efficacy and goal-orientation training on negotiation skill maintenance: What are the mechanisms?. *Personnel Psychology*, *50*, 955–978.

Tabernero, C., & Wood, R. E. (1999). Implicit theories versus the social construal of ability in self-regulation and performance on a complex task. *Organizational Behavior and Human Decision Processes*, *78*, 104–127.

Tannenbaum, S. I., Beard, R. L., McNall, L. A., & Salas, E. (2010). Informal learning and development in organizations. In S. W. J. Kozlowski & E. Salas (eds.), *Learning, training, and development in organizations* (pp. 303-331). New York: Taylor and Francis.

Unger, J. M., Keith, N., Hilling, C., Gielnik, M. M., & Frese, M. (2009). Deliberate practice among South African small business owners: Relationships with education, cognitive ability, knowledge, and success. *Journal of Occupational and Organizational Psychology*.

van Dijk, V. (2010). Learning the triage procedure: Serious gaming based on guided discovery learning versus studying worked examples (Unpublished master's thesis). Universiteit Utrecht, Utrecht, the Netherlands.

Wang, Y. B., Zhang, W., & Salvendy, G. (2010). A Comparative Study of Two Hazard Handling Training Methods for Novice Drivers. *Traffic Injury Prevention*, *11*, 483–491. doi: 10.1080/15389588.2010.489242

Weaver, J. L., Bowers, C. A., Salas, E., & Cannon-Bowers, J. A. (1995). Networked simulations: New paradigms for team performance research. Behavioral Research Methods, Instruments, & Computers, 27, 12–24.

Wood, R., & Bandura, A. (1989). Impact of conceptions of ability on self-regulatory mechanisms and complex decision making. *Journal of Personality and Social Psychology*, *56*, 407–415.

Wood, R. E., Kakebeeke, B. M., Debowski, S., & Frese, M. (2000). The impact of enactive exploration on intrinsic motivation, strategy, and performance in electronic search. *Applied Psychology: An International Review, 49*, 263-283.

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist, 25*, 3–17.