GEL, Adaptable Expertise and Transfer of Training

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The Guided Experimental Learning (GEL) training system is designed to promote the development of adaptable experts who not only learn to perform in routine situations but also are able to apply their skills and knowledge when conditions shift and change. GEL mandates that all trainees be provided with both conceptual and procedural knowledge about how to perform tasks and solve problems. The fact that GEL provides novice trainees with a specific, effective way to initially solve problems and perform tasks is viewed by some as preventing or restricting the adaptable application of knowledge after training. The purpose of this brief paper is to examine the most current evidence for training strategies that produce adaptability. The discussion is structured around evidence that is available to answer a number of questions about adaptable expertise and GEL.

1. Are some experts more adaptable than others?

Solid research evidence supports informal observations that some experts are more adaptable than others. For example, Hatano and others (Hatano, 1982; Hatano & Inagaki, 1986, 2000) have described the differences between "routine expertise" and "adaptive expertise." Routine expertise manifests as high proficiency within a stable environment that does not involve the changes and adaptations often necessary in more fluid contexts such as those faced by military commanders and other decision makers in the field. Although typical tasks are completed with a high level of proficiency, when the task constraints change, these individuals are not able to maintain their high levels of performance. Besnard (2000; Besnard & Bastien-Toniazzo, 1999; Besnard & Cacitti, 2001) has studied extensively the constraints of routine expertise in troubleshooting. After recording the time and sequence of troubleshooting steps taken by novices and experts, he found that some experts tended to take longer than novices to find faulty components with unusual errors, because they exhibited a frequency bias, spending more

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time examining components typically responsible for faults (Besnard, 2000; Besnard & Bastien-Toniazzo, 1999).

In contrast, adaptive experts are highly successful even under novel conditions. Bereiter and Scardamalia (1993) observed that while experts have automated procedures within their domain, their skills are highly adaptable to complex, ill-structured, and novel situations. They reason that flexibility is due to the fact that minimal space in working memory is occupied by the novel challenges, thereby allowing mental effort to be reinvested to draw on conceptual knowledge related to problems in order to make flexible adaptations in their solution strategies. In one example, Gott, Hall, Pokorny, Dibble, and Glaser (1993) reported that highly successful air force technicians were able to adapt knowledge to novel situations despite high levels of consistent, effortless performance at more routine problems.

2) Does the learning of procedures prevent or inhibit flexibility?

The answer to this question is controversial but enough evidence exists to suggest that, depending on how procedures are trained and learned, they not only do not prevent but may be necessary to facilitate adaptable expertise for most trainees.

Ericsson (1998, 2004) who studies advanced expertise has argued that "automaticity" (the learning of procedures and practicing them until they are automated) prevents the development of adaptable expertise. He even argues that flexibility requires that experts avoid automating procedures. Ericsson's conclusion is based entirely on his personal observations of advanced experts and he provides no evidence to support his position. Ericsson's view is a major departure from our current understanding about the nature of expertise and the explanations about why experts are so successful at what they do. In brief, most people who study expertise believe that the evidence best supports the view that experts succeed because of a large body of automated knowledge which they acquire over many years, often by trial and error. Thus, expertise without procedural automaticity may be psychologically impossible (see for example the comprehensive review by Kirschner, Sweller & Clark, 2006; Clark & Elen, 2006).

A large body of empirical research on expertise and transfer supports the conclusion that procedures do not inhibit (but instead support) flexibility. Hatano & Inagaki, (1986, 2000), Besnard & Bastien-Toniazzo (1999), Bereiter and Scardamalia (1993), Hall, Pokorny, Dibble, and Glaser (1993), Perkins and Grotzer (1997) and De Corte (2003; Masui & De Corte, 1999), among others, have offered evidence that more adaptable experts acquire and apply both procedural and conceptual knowledge differently than less adaptable experts. In a recent review of research on the development of advanced expertise, Feldon (2007) tackles the flexibility question and states:

> "… careful empirical studies of acquisition and transfer for automated skills demonstrate that limited transfer of automated procedures to novel cues and circumstances can occur (e.g., Anderson, 1987; Cooper & Sweller, 1987; Fisk, Lee, & Rogers, 1991; Kramer, Strayer, & Buckley, 1990; Schneider & Fisk, 1984). Further, because complex skills are inherently compilations of many distinct subskills, any particular performance may represent one of three possible paths. These paths are (1) fully automated processes, (2) serial execution of automated and consciously mediated subskills, or (3) simultaneous execution of

> both automatic and conscious elements. (Anderson, 1995; Bargh & Chartrand, 1999; Cohen, Dunbar, & McClelland, 1990; Hermnns et al., 2000; Shiffrin & Dumais, 1981)." (p. 97).

Feldon goes on to suggest that when experts learn and automate procedures, they are able to apply them without "thinking" while using their conscious, conceptual knowledge to adjust "subskills" (chunks of larger procedures) to solve novel problems. Without automated procedures, the complexity involved in handling novelty has been found to cause "cognitive overload" and defeat performance (Sweller, 2006; Clark, 2001).

3) What training strategies have been found to increase the flexibility of experts?

After an extensive review of the transfer literature, Perkins and Grotzer (1997) and Clark & Blake (1997) argue that flexibility can be taught in a way that facilitates the solution of novel and challenging problems. They describe strategies that have been used in successful programs. De Corte (2003; Masui & De Corte, 1999) draw on these reviews and others to provide a description of aspects of learning environments that facilitate the development of the necessary characteristics for successful transfer of existing skills to novel problems in which orienting (problem framing) and self-judging were taught according to the following guidelines:

- ***Environment***: Skills and knowledge instruction must be taught in environments that reflect the application environment as much as possible to highlight the importance of relevant cues.
- ***Motivation****:* Task motivation must be linked to tangible and personally relevant outcomes.
- *Increasing novelty*: Training must be sequenced to allow for gradually increasing levels of novelty and challenge (see also extensive research on the design of instruction using worked examples: Atkinson, Derry, Renkl, & Wortham, 2000; Paas & van Merrienboer, 1993; Sweller, 1999).
- ***Variable Practice***: The characteristics of learning and performance tasks must be variable over the course of instruction to maximize opportunities to develop flexibility.
- ***Targeted Feedback***: Students must be provided with opportunities to receive targeted feedback and consider alternatives to more effective approaches.

These guidelines reflect a similar list suggested by Merrill (2006) who analyzed the key features of new training design systems that appeared to be successful at developing adaptable expertise and recommended similar design features.

4) How does GEL attempt to implement training strategies that have been found to increase flexibility?

Based on the DeCorte (2003) and Merrill (2002) design criteria and the studies cited above, the GEL design system attempts to promote the development of adaptable expertise through applying all of the empirically identified training methods that promote flexibility:

- ***Environment***: Where possible, GEL lessons are situated in the environment where skills and knowledge will be applied. Environment is reflected in a series of application scenarios (similar to case studies) and demonstration video's. GEL also attempts to prevent cognitive overload by focusing novice trainees on only the key elements of an application environment.
- ***Motivation***: GEL requires motivating statements of tangible and personally relevant "benefits and risks" associated with each task to be learned.
- ***Increasing novelty***: GEL requires the collection of five, increasingly novel and challenging scenarios (similar to case studies or authentic problems) for use in practice exercises, checks on learning and testing. The variation in novelty for GEL course is greater than any other design system.
- ***Variable Practice***: GEL requires both part task practice (during lessons) and whole task practice where trainees are required to apply what they have learned as they attempt to solve the problems and scenarios described in the point above.
- ***Targeted Feedback***: GEL requires targeted feedback on trainees attempts to apply what they have learned from demonstrations and attempts to practice when given scenarios and problems. GEL feedback strategies draw on the most current research on feedback and performance to support adaptable expertise.

Additional features of GEL designed to promote adaptable expertise:

- ***Analogical Connections to Prior Knowledge***: GEL requires the presentation of analogies and varied examples in each lesson in order to help trainees connect to prior knowledge and to promote adaptable application of skills and knowledge. The strategy reflects research by, for example, Gentner et al (2003).
- ***Open Questions during Feedback***: When application practice feedback is given, trainees are asked for their reasoning about their problem solving strategies and are given the opportunity to examine alternatives rather than being "told the correct path".

We have subjected the GEL system to intense studies of learning and transfer in high stakes expertise areas such as the training of trauma surgeons (see for example a report of a study by Velmahos et al, 2003). Our data indicates that GEL trained surgeons learn faster, and make significantly fewer mistakes in authentic, complex, novel trauma situations after training than surgeons trained by experienced experts who demonstrate the procedure and then ask the students to perform in a "see one, do one, teach one" approach.

Conclusion:

Our view is that most training systems focus primarily on the learning of conceptual knowledge (concepts, facts, processes and principles) and not on learning "how" to solve problems and handle complex, real world scenarios. Clark and Elen (2006) discuss this issue in depth in a review of current research on complex learning. Current training and Field Manuals describe systems and suggest "what to do" in some situation and expect that trainees will figure out "how" to perform when in the field (often while they are handling extremely volatile, uncertain, complex and ambiguous situations). Some training methods, such as those used in clinical medicine, provide expert-led demonstrations and require practice and feedback. Learning how to apply knowledge flexibly in authentic situations requires that trainees first learn how to handle routine situations and only then tackle complex scenarios and solve complex problems. Once trainees have learned at least one way to handle a scenario or solve a problem they can begin to learn how to flexibly apply that way to handle novel and unexpected events. Current evidence best supports the claim that when training systems provide novice to intermediate trainees with many different approaches to solving problems or handling a complex scenario - or require them to construct their own approaches, the most common effect is cognitive overload and a failure to learn (Sweller, et al, 1990; Sweller, 2006; Clark, 1991). It is the case that a very small minority of trainees sometimes succeed in multiple scenario, complex training environments. Yet the fact that a small minority of highly intelligent, high prior knowledge and motivated trainees succeed (e.g. Mayer, 2004; Klar & Nigam, 2004) is not an argument for using the approach for all trainees nor is it evidence against the "teach one way to do it first and then work for flexible adaptation" approach used in GEL. The best evidence supports the claim that while GEL may not have value for top experts in a field and/or for a small minority of the most exceptional trainees, it will not harm their learning (e. g. Velmahos et al, 2004)

The designers of GEL are very willing to modify the system based on compelling evidence that a feature of GEL does not contribute to learning or transfer and/or some additional feature would significantly enhance its success. We are currently subjecting GEL to intense evaluations in leadership courses. We invite an evidence-based dialogue on GEL and are committed to continual improvement.

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