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Yes we can: Improving performance in dynamic tasks

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ABSTRACT

Facilitation, a special kind of decisional aid, is all forms of information, strategies, and heuristics delivered by a facilitator to aid decision makers in dynamic decision environments. It is assumed that facilitation has profound effects on decision making, but these effects are understudied and empirically unproven. By incorporating the three levels of facilitation, pre-task, combined pre-task and in-task, and combined pre-task, in-task, and post-task, in the design of a simulation-based interactive learning environment (ILE), this study provides an empirical, laboratory-experiment-based evaluation of the effectiveness of facilitation on performance in dynamic tasks. We develop and use a comprehensive model consisting of four evaluation criteria: task performance, structural knowledge, heuristics knowledge, and transfer learning. We find that the subjects provided with combined pre-task, in-task, and post-task facilitation performed the best, followed by those provided with combined pre-task and in-task facilitation. Contrary to the hypothesis, subjects provided with pre-task facilitation performed poorly.

1. Introduction

Managers and policymakers face problems that are increasingly complex and dynamic in nature. In a dynamic task, a number of decisions are required rather than a single decision, decisions are interdependent, and the environment in which a decision is set changes either autonomously or because of the decision made or both [7,15,49]. For instance, inventory management, fire fighting, software development, and sustainable use of renewable resources are all dynamic tasks. Improved decision making in these tasks is an absolute necessity for the success of decision makers and the performance of their organizations.

The recognition that these real world dynamic tasks (e.g., medical emergency preparedness, project management, and long term planning and strategic decisions in organizations) do not lend themselves well to real world experimentation has long motivated the use of computer simulation based interactive learning environments (ILEs) as decision support systems. Moreover, in dynamic tasks, managers need ways to test their decision strategies before a costly and often irreversible implementation follows. Computer simulation-based interactive learning environments provide a potential solution here. For instance, ILEs are often used to improve decision making in dynamic tasks [12,13,16,25,50]. We use "ILE", a special kind of decision support system, as a term sufficiently general to include microworlds, management flight simulators, simulation-based learning laboratories and any other computer simulation-based environment — the domain of these terms is all forms of action whose general goal is the facilitation of learning [25]; ILEs allow the compression of time and space and provide an opportunity for managerial decision making in a non-threatening way [25].

Learning is a process whereby knowledge is constructed by the transformation of experience [32]. Simulations in general and ILEs in particular are one form of experiential learning. In an ILE session subjects make a series of decisions and have access to the instantaneous feedback. Subjects also have the opportunity to evaluate and reflect on their performance in the post-simulation debriefing session. Despite promising an increasing interest in ILEs, their benefit to the decision making and learning in complex, dynamic tasks is far less promising [5,6,16,33,48].

The increasing urge to improve the efficacy of ILEs has led researchers to suggest improvements. One such way to improve the efficacy of an ILE is to incorporate *structured and systematic facilitation* [10,23,50,56]. Facilitation, a special kind of decisional aid, is all forms of information, strategies, and heuristics delivered by a facilitator to aid subjects' decision making and learning in a task. In dynamic decision environments, facilitation can provide decisional aid at three levels — pre-task, in-task, and post-task levels [50]. For instance, in the aviation industry, learning "how to fly a plane" requires the acquisition of expertise on a complex, dynamic task. A trainee pilot begins training with classroom instructions and intensive simulator-based learning, a pre-task level facilitation. Next, hands-on-practice in the cockpit follows but always with the help of an experienced pilot, an in-task level facilitation. Finally, after the flight is over, performance is analyzed and feedback is provided, a post-task level facilitation.

Although research on dynamic decision making and learning in ILEs has embraced the concept of facilitation, it has generally been deficient in several ways. First, while prior research has evaluated

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pre-task and post-task level facilitation in the context of dynamic tasks (e.g., [11,20,49]), efficacy of in-task level support has rarely been tested. Second, no prior study has explored efficacy of facilitation as a combined pre-task, in-task, and post-task facilitation hypothesis. Third, prior research has often relied on a limited assessment of performance outcomes, focusing frequently on game performance to index ILEs' effectiveness.

The present study contributes by addressing some of the deficiencies noted above. Specifically, we investigate the relative efficacy of three decision support alternatives – (i) pre-task, (ii) combined pre-task and in-task, and (iii) combined pre-task, in-task, and post-task level facilitation – in the context of a dynamic task. In addition, this research distinguishes the independent effects of facilitation alternatives on the multidimensional decision outcomes: task performance, structural knowledge, heuristics knowledge, and transfer learning. This paper thereby fills an extant gap in research on decision making in dynamic decision environments.

2. Theoretical premise and hypotheses development

2.1. Background concepts and definitions

We aim to investigate the relative efficacy of three decision support alternatives in promoting decision making and learning in dynamic tasks. Consistent with prior studies on dynamic tasks, subjects' decision making is conceptualized as their ability to do the task [1,14,50,59]. Maximizing the profit of a firm or doing the task with minimum cost or in a minimum time is a commonly used example of task performance measures.

On the other hand, learning bears on multiple perspectives [30,44,56]. We may consider learning either as a progression towards expertise [29,60] or as becoming part of a community of practitioners [55]. Drawing upon the modern objective-oriented 'constructivist' approach to learning [57], we follow Sternberg's view of learning. In Sternberg's view, people are not really experts or non-experts, but rather are experts in varying degree — prototypes [60]. Prototypic attributes may vary across domains, times, and space and thus, are dynamic in nature. A prototype view of expertise implies a broader view of learning and can well accommodate the diversity of skills and knowledge acquired by decision makers through participation in ILE sessions.

We consider *transfer learning* as our main learning outcome measure. Transfer learning measures how well decision maker learn from a previous task by making them attempt another task, either in the same domain or a different domain [25,66]. Most education and training programs aspire to transfer learning [56,57,67]. Graduates are expected to do well in their jobs by applying the skills they learned in college. Pilots, after intensive simulator-based training, are assumed to transfer the acquired skills to actual plane flying task. In fact, if the skills developed by education and training programs do not transfer beyond the training context, much of the investment may be considered wasted, as noted in a National Research Council report on enhancing human performance [65]. Training with ILEs is no exception, so transfer learning is our major outcome measure in this research study.

We also include structural knowledge and heuristics knowledge as measures to better capture a range of expertise development. *Structural knowledge* pertains to knowledge about principles, concepts, and facts about the underlying model of the task system (e.g., in our dynamic task, the concept of carrying capacity refers to the maximum population of "fisheries" that the "fishing area" can sustain indefinitely). *Heuristics knowledge* concerns how decision makers actually control a task (e.g., strategy that a subject used to order new ships is an example of heuristics knowledge). Therefore, improved performance and learning in dynamic tasks could be evident from an improvement in any of these dimensions of expertise [56,63,64].

2.2. Pre-task level facilitation in dynamic decision environments

Pre-task level facilitation is conceptualized as information provided by the facilitator to a decision-maker about the model of the task prior to performing the task [11,20]. It is typically conveyed through a set of heuristics for effectively performing the task. Pre-task level support may help the subjects perform better in dynamic decision environments at least in two ways. First, providing the subjects information about the central variables of the task system as well as the relationships between these variables, the task may become salient. Subjects perform better in decision-making environments where the relationships among the key variables of the task system are made more salient than those with non-salient task systems [20,21]. Second, pre-task facilitation may reduce cognitive load of a subject because a substantial amount of the information the subject has to infer through the complex interactions with the ILE is already transmitted through prior instructions. Studies conducted in a variety of tasks have found that the performance of the subjects provided with task heuristics is better than what would be achieved through task experience [4,46].

In dynamic situations, therefore, the effectiveness of pre-task facilitation lies in its ability to convey a model of the task system to the decision-maker. This enables the decision-maker to understand the key relationships prior to the interactions with the task system. Pre-task facilitation can thus serve as an effective method of planning overall strategy. This conception of pre-task facilitation embodies the combined characteristics of task information or feed forward [54] and cognitive information including heuristics [4,26,31,53]. Information about the causal relationship between the variables of the task system adds to the task transparency. Increased task transparency leads to improved performance in dynamic tasks [20,21,50]. Moreover, an appreciation and understanding of key structural elements of the task system (e.g., delays give rise to oscillations in the task system behavior (output)) are not only useful in developing better structural knowledge but also enhance the subjects' transfer learning skills [21,42]. Thus,

H1a. Subjects receiving pre-task facilitation will outperform those without pre-task facilitation on task performance.

H1b. Subjects receiving pre-task facilitation will outperform those without pre-task facilitation on structural knowledge.

H1c. Subjects receiving pre-task facilitation will outperform those without pre-task facilitation on heuristics knowledge.

H1d. Subjects receiving pre-task facilitation will outperform those without pre-task facilitation on transfer learning.

2.3. In-task level facilitation in dynamic decision environments

In-task level facilitation attempts to improve the individual's decision-making performance by: (i) making the task goals explicit at early stages of learning, (ii) helping keep track of goals during the task, and heightening the importance of relevant features of the task so that the learner can assess what action is appropriate [10,49,50]. Such facilitation can also help decision-makers avoid long episodes of counter-productive floundering with the task [56].

In the absence of in-task facilitation, self-directed learners face at least three problems: (i) the "motivational paradox" (the goal of accomplishing the task conflicts with the goal of learning the system), (ii) the "assimilation paradox" (new knowledge is distorted to fit with existing mental models), and (iii) learners are often unaware of what they do not know [8]. Previous research has reported the positive effects of facilitation in overcoming the abovementioned difficulties but only in static environments [16,23]. No prior study has evaluated, for example, the effects of in-task level facilitation in the context of a dynamic task.

In dynamic environments, the effectiveness of in-task level facilitation lies in its ability to provide appropriate goal-directed and diagnostic