User Interface Designs, Task Categories and Training

Chapter 3
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ABSTRACT

This chapter provides a preliminary framework for learner centered user interface design across a variety of training categories. To arrive at this framework, the authors explore (1) user interface design principles and the extent to which they apply to learning environments, (2) the learner centric psychological principles that should be included in the design of learner interfaces, and (3) methods by which training tasks are categorized. The overarching premise of the framework is that designs that are compatible with the psychology of learning promote learning, and ultimately performance, better than those that do not. This seemingly simple concept is sometimes in conflict with user interface design principles for other purposes, such as general purpose websites or marketing campaigns. The framework results in a notional configuration of 27 learner centered training interfaces, which are analyzed for their relevance to user interface design. The chapter concludes with a call for further research to determine best practices in learner interface design.

INTRODUCTION

Digital information and its delivery are ubiquitous in modern society. From the moment a digital radio or cell phone awakens you, to your daily work routines, to checking on your Facebook friends, our lives are becoming one never-ending interface to the digital world. Advancements, enhancements, and extensions of this trend are relentless. The delivery of education and training content in digital form is clearly part of this trend, as testified by the explosion of the e-learning marketplace. E-learning holds much promise for the training of the workforce, for the education of youth, and

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for the development of society (Wisher & Khan, 2010). In Badrul Khan's popular depiction of an e-learning global framework through his octagon model, interface design plays a prominent role (Khan, 2001). The challenge of designing interfaces specific to the needs of the digital learner is worth examining.

The chapter takes a holistic view of this challenge. Our central question concerns the optimal 'user interface' between a learner and learning content. Do user interface design principles for general opertional use apply to learning environments? What factors from a learner-centric perspective should be considered as an underpinning to an ideal interface design for learners? Our examination, then, is from a learning perspective, although from more of a training rather than from an educational point of view. The objective in training is to systematically acquire knowledge, skills, rules, concepts, and attitudes that result in improved performance in another environment. We focus on the application of technologies, specifically information and communications technologies, to bring about this systematic acquisition. What matters for the trainee to interface with digital learning content is our concern.

This chapter is organized into a background section and three main sections. The background section covers learner-centered psychological principles; the user-centrist theme is used throughout the chapter. For our purposes, the user is the learner. A learner centered approach begins with an understanding of how the mind functions, so the natural tendencies of the learner should be factored into designs of the interface to learning content. The background covers some psychological principles of learning centered around the learner rather than the instructor. This analysis is further narrowed to what matters most in training.

The first main section considers relevant aspects from the user-interface-design literature related to simulations, in particular the issue of physical fidelity. The section briefly covers the fidelity question as it relates to reproducing the same cognitive experience by the user/operator/learner. Should the intention be to make the experience and interactions intuitive and efficient, in terms of achieving learning outcomes, or merely replicate the actual environment at a lower cost? The second section, the most extensive, reviews relevant training analysis literature, drawing from the many models that have been proposed for categorical descriptions of the elements of training. The intention is to recognize these contributions and what they can offer to categorical descriptions of learner interfaces. The third section attempts to unite the concepts from the first two sections and form a holistic view of the relationship between interfaces and learning content. This is an ambitious goal, and the limited space allotted for this chapter will allow us to only introduce many of the key areas and examine only a subset of interface configurations. The objective of this chapter is to establish a framework for the many factors that underlie the successful development of the learner interface to digital learning content for the purpose of training.

BACKGROUND

In the past century, significant progress was made in understanding the training of skills and abilities, even performance at an expert level (Clark & Wittrock, 2000). The psychological principles of learning and instruction have led to cognitive models that focus on the critical roles of the learner's cognition, including motivation, memory, comprehension, attention, and the active construction of meaning and understanding (Newell, 1990). These models converge on the human memory system and the processes that attend, transform, store, and retrieve information during learning and later during performance on the job. Note that such models focus on the capacity of the individual to learn and perform, and thus can be viewed from a learner-centered point of view.

Toward the end of the past century, the field of interface design grew from an isolated subarea of ergonomic design to a new area of inquiry driven by software engineering (Shneiderman, 1992). Much of the focus was on human computer interaction, which sought interfaces that were comprehensible, predictable, and controllable. A good deal of the progress in understanding human cognition also contributed to modern views of interfaces to all sorts of devices, as exemplified in Don Norman's stimulating *The Psychology of Everyday Things* (Norman, 1988). It is interesting to note the parallels between guidelines for creating 'user' interfaces to those for creating 'learner' interfaces. Both seek to identify relations between design features and the human information processing system. As we will demonstrate, there are limits to the analogy and some contradictions in what is best for the individual dealing with content through an interface. Our overarching premise is that designs that are consistent with the manner in which the human mind works promote performance and learning better than those that are not.

Learner-Centered Psychological Principles

Nearly two decades ago, the American Psychological Association (APA) announced a set of 14 Learner-Centered Psychological Principles (Alexander & Murphy, 1994; APA, 1993). These 14 principles summarize research from the fields of learning and instruction, motivation, and development, many of which had underpinnings in cognitive psychology. At the same time, cognitive psychology was influencing the field of user interface design, seeking to make users 'smarter' (Norman, 1993). The APA principles address areas such as promoting curiosity and intrinsic motivation, linking new information to old in meaningful ways, providing learner choice and personal control, cultivating social interaction, advancing thinking and reasoning strategies, constructing meaning from experience, and taking into account learner social and cultural background. These 14 principles have been echoed in many learning theories, particularly those focused on teaching complex material such as cognitive learning strategies (Merrill, Reiser, & Merrill, 1995), constructivism/learner-centered education (Dimock and Boethel, 1999), experiential activities (Van Velsor & Guthrie, 1998), and cognitive flexibility theory (Spiro, Feltovitch, Jacobson, & Coulson, 1992). These 14 principles have significant promise for Web-based instruction (Bonk & Reynolds, 1997) and provide a sound basis for online instruction.

Complementing the learner-centered psychological principles, many educational technologists are advocating the need to shift from instructor-centered to student-centered approaches. Learner-centered pedagogy asks what students need to learn, what their learning preferences are, and what is meaningful to them. Online instruction provides opportunities for learning materials, tasks, and activities to fit individual learning preferences. Of course, the user-as-learner interface is a critical feature and it is often not considered sufficiently in online education and training.

In accordance with the learner-centered movement, online tools should provide opportunities to construct knowledge, actively share and seek information, generate a diverse array of ideas, appreciate multiple perspectives, and engage in social interaction and dialogue. Simply stated, technology rich environments have the capacity to support learner engagement in meaningful contexts. For a more detailed look at the examples, functions, and supporting research for learner-centered environments, see Hannafin and Land (1997).

The 14 principles can be divided into four factors. The factors and related principles are:

1. **Cognitive and metacognitive factors:** the nature of the learning process, the goals of the learning process, the construction of knowledge, strategic thinking, thinking about thinking, and the context of learning.

2. **Motivational and affective factors:** motivational and emotional influences on learning, intrinsic motivation to learn, effects of motivation on learning.
3. **Developmental and social factors:** development within and across physical, intellectual, emotional and social domains, social interactions and interpersonal relations with others.
4. **Individual differences:** in learning, diversity in linguistic, cultural, and social backgrounds, and diagnostic, process, and outcome assessments as an integral part of the learning process. For a more detailed discussion of these principles see Bonk, Wisher, and Lee (2004).

For our purposes, we have selected three principles for inclusion in our crosswalk to heuristics for interface designs and categories of training. A more complete analysis, of course, would include all 14 principles. Multiplying all the possible combinations from the other two sources would involve many thousands of instances, the analysis of which is well beyond the scope of this chapter. Our goal again is to create a framework of the many core elements that form the foundation for interfaces between a learner and training content. The three principles are: Construction of Knowledge – or how the user can link new information with existing knowledge in meaningful ways; Context of Learning – or the environmental factors such as culture, technology, and instructional practices that influence learning; and Individual Differences – the different strategies, approaches, and capabilities for learning that are a function of prior experience and heredity. The fourth area of developmental and social is less related to factors that a training developer or interface designer can directly control and therefore is not addressed here.

USER INTERFACE DESIGNS

Every system has an interface to the user. It may be a simple on-off switch, knobs and dials, or sophisticated screen dialogues to computer systems that determine how people operate and control the system. One common interface design principle is to keep the interface simple and straightforward. Basic functions should be immediately apparent. These suggestions are difficult to refute, unless you are providing training on a system that has already been designed, and which may not have followed the keep-it-simple advice in creating its user interface. This can be the case in simulations of actual equipment usage designed many years ago, such as the control room for a complex operational setting. Do you render an understanding of the mechanics of the system in an easy-to-use interface for the simulation or do you mimic the configuration of the actual system?

The human factors advice on the design of interactive software often applies to either an operating or a learning environment. The methods to develop and assess interfaces, interactive styles, direct manipulation for graphical user interfaces, and design considerations for effective messages, consistent screen design, appropriate colors and so forth can impact the success of users in either environment. There are, however, limitations. For example, Nielsen (1999) identifies ten general principles, really heuristics, for interface design. One heuristic is: Recognition rather than Recall, the rationale being to minimize the user's memory load so that the user should not need to remember information from one part of the dialogue to another. This contrasts with strong evidence from the experimental psychology literature suggesting a different user design in order to enhance learning. Specifically, requiring a user to retrieve some piece of information can directly strengthen the memory for that information and slow the rate of forgetting (Rohrer & Pashler, 2010). At some point, learning depends on remembering information. Ways to facilitate this, rather than avoid it, are keys to learning.

Another counter intuitive example concerns the user interface design heuristic of Nielsen (1999) concerning Aesthetic and Minimalist Design, which advises that dialogues should not contain information which is irrelevant or rarely needed. In multimedia learning, this has been termed a 'seductive detail' or "highly interesting and entertaining information that is only tangentially related to the topic but is irrelevant to the author's intended theme" (Harp & Mayer, 1998, p.1). Its best use in training depends on the intended purpose of the training. Capturing the attention of the learner is important for maintaining learner interest, which in turn leads to deeper processing of information and better learning and transfer. There is evidence that seductive details can have a facilitative effect on transfer of performance from the learning phase to the application phase (Towler et al, 2008). The category of training, then, can override some more general guidelines for interface design.

Fidelity in Design

Interface design is a critical component in simulation that can be used for training. The way in which learners interact with simulated environments can enhance or hinder learning and transfer. While the specific components of a simulator interface will vary greatly depending on the nature of the task that is being trained, one issue that is consistently an issue across all simulator interface designs is that of fidelity. Currently, there is little agreement on what fidelity in simulation is, and how it applies to training (Dahl, Asos, & Svanæs, 2010). Much of the focus of technology developments in simulation is focused on physical fidelity. Physical fidelity is the extent to which a simulator realistically reproduces the aspects of the environment in which the actual task will be conducted (O'Sullivan, Dingliana, Giang, & Kaiser, 2003). While it is intuitively appealing to consider physical fidelity as an important characteristic of simulation in order to facilitate learning and transfer, a growing body of research has found evidence to the contrary (Hays, Jacobs, Prince, & Salas, 1992). Specifically, some simulations that include rich, high-detail environments (Mania, Badariah, Coxon, & Watten, 2010) and easy-access to task-related information (Waldron, Patrick, Duggan, Banbury, & Howes, 2008) have been shown to reduce knowledge retention and skill transfer to the actual task environment.

One explanation of the disappointing results associated with focusing on physical fidelity is that simulations high in physical fidelity may still not reproduce the cognitive processes associated with a given task. Fidelity with regard to cognitive, affective and psychomotor properties (Bloom, 1956) is called psychological fidelity (Kozlowski & DeShon, 2004). The use of psychological fidelity represents a shift from implicit to explicit modeling of the environment. Physical fidelity is implicit in that it implies that the more accurately an environment is represented physically, the higher degree of task related learning will take place. Alternatively, psychological fidelity is explicit, in that it uses existing theory and systematic analysis of tasks in order to create direct theoretical relationships between aspects of a simulation's design and the task-relevant knowledge, skills, and abilities that will be learned. Kozlowski and DeShon (2004) identified three primary theoretical branches by which this can be accomplished. These include theories, of learning, motivation, and performance, instructional design, and metacognitive theories or heuristics in training of adaptive teams.

The development of a user-interface for a simulation must begin with a thorough cognitive task-analysis (Kozlowski & DeShon, 1999). This process identifies the cognitive processes associated with the task that is to be trained. Once the specific cognitive processes have been identified, the interface and training tasks should be designed in such a way that the cognitive load is reduced for non-task related processes and increased for highly task-related processes. This may seem counterintuitive because relevant training outcomes such as the development of self-efficacy (Bandura, 1997) are related to the successful completion of training tasks (Godstein & Ford, 2002). However, research has indicated that reducing the cognitive load with task-related processes leads to lower retention and skill transfer (Waldron et al., 2008).

As stated before, many design principles and heuristics stress that access to task-related information should be as easy and intuitive as possible. This philosophy may decrease psychological fidelity for tasks in which it is difficult to extract relevant information, thereby reducing skill retention and transfer. As a result, it is recommended to avoid interface design heuristics that encourage this. Alternatively IBM has created a set of eleven "Design Principles for Tomorrow" (Stasko, 1997). These principles stress the congruence of cognitive processes in the user interface with the cognitive processes associated with the task to be trained. These principles are listed below:

1. **Simplicity:** Don't compromise usability for function
2. **Support:** User is in control with proactive assistance
3. **Familiarity:** Build on users' prior knowledge
4. **Obviousness:** Make objects and their controls visible and intuitive
5. **Encouragement:** Make actions predictable and reversible
6. **Satisfaction:** Create a feeling of progress and achievement
7. **Accessibility:** Make all objects accessible at all times
8. **Safety:** Keep the user out of trouble
9. **Versatility:** Support alternative interaction techniques
10. **Personalization:** Allow users to customize
11. **Affinity:** Bring objects to life through good visual design

For our purposes, we have again selected three principles for inclusion in our framework to crosswalk between learner-centered psychological principles and categories of training. A more complete analysis, of course, would include all 11 principles, and other sources of guidelines and heuristics that were not included in this brief review. The three principles selected from the IBM list are: Familiarity – the relationships among user interface objects should allow users to rely on their previous experience in the domain; Versatility – allow users to choose the method of interaction that is most appropriate to their situation; and Affinity – visual design should communicate the function of the user model without ambiguities. The framework is developed later in the chapter.

CATEGORIES OF TASKS

The goal of this section is to present task categorization criteria and subsequent task categories that describe the world of training, at least in terms of tasks. Although there are numerous categorization schemes for tasks, our interest was in isolating those with factors that address whether training can be cost-effectively delivered through technology, and thus require a user interface. We searched a wide range of task categorization methodologies and sought to pick out specific criteria that make one group of tasks unique from another group in terms of how they might best be trained with current instructional practices.

The following review discusses the process and outcomes of a literature search for task classification criteria. This includes academic journals, applied texts and case studies, and military research articles; it covers both empirical and theoretical works independent of the purpose of the classification.

Search Methodology

The literature review took place in multiple steps. First, we prepared a list of journal articles, book chapters, military research reports, and other case studies. These were gathered by searching databases such as PsycINFO, Google Scholar, and the U.S. Military's Defense Technical Information Center. Additionally, we identified case studies by searching the standard Google search engine. Search terms included keywords from e-learning, training task analysis, and training task categories. These terms include task classification models, media selection models, and other factors affecting retention and complexity of tasks. Additional sources were identified by examining prevalent books for chapters pertaining to training, adult education, and job analysis. Results of the searches were screened to determine if they contained information relevant to the objectives of the current literature review.

Articles that presented task classification methodologies were given a more detailed review. Each article was reviewed to determine what, if any, task classification criteria were used. Models with specific criteria are detailed here along with an assessment as to the extent to which the criteria: 1) have the potential to create unique classes that may vary in terms of the media that would be selected for training, 2) produces discrete categories versus general descriptions, 3) are sufficiently important to be included in a categorization schema that will result in a manageable number of categories (so as to not defeat the purpose of creating categories in the first place), 4) Enduring and static - not likely to change in different contexts or environments in the near future.

Results of Search

Numerous examples of task classification criteria are reported in the contemporary literature. Classification systems can be very general in scope or very specific. They also vary in focus and purpose. Listed below are several classification criteria that have been found to be useful when grouping tasks for purposes of job analysis or training development. We should note that there are ample examples of media selection models that recommend delivery media for virtual methods of training, but these are predicated on the assumption of a virtual approach in the first place.

The search resulted in nine broad schemes to describe the world of training:) Levels of analysis; 2) Time and motion analysis; 3) Worker functions, or functional job analysis; 4) Task characteristics; 5) Position analysis questionnaire; 6) Blooms taxonomy; 7) Cognitive task analysis; 8) Level of interaction; 9) Perishability and task retention models. The analysis presented below begins with classification schemes at a top-level view of training, based on how work is organized and how workers function. Characteristics of tasks are then reviewed, including domains, intellectual behaviors, task complexity, interactions during learning, and skill retention dynamics.

Levels of Analysis

Levels of anlaysis is one of the basic ways to describe how work is organized. This classification system is hierarchical, in that each level is made up of units of the next lower classification. An element is the most basic form of classifying work and refers to specific motions that make up tasks. Activities are units of work that are made up of multiple elements. While the more general categories are useful for understanding how work is grouped, training is typically focused on tasks, activities, and elements

Altogether, nine levels of analysis were identified: Branch, Group, Series, Job, Position, Duty, Task, Activity, and Element. For example, Branch is the most general form of work, such as Software Engineering. Position refers to a job this is specific to an individual, such as Programmer, and Activity is composed of multiple elements that make up a more complete unit of work, such as Documentation. This categorization system works well for describing what people do in their jobs but it is not until reaching the Task level that user interface design needs serious consideration.

Time and Motion Analysis

Time and motion analysis categories refer to the amount of time a given task will take as well as what and how many motions are required for the different tasks. Time and motion studies were originally introduced by Frederick Taylor (1911) and still have relevance in today's workplace. Categories such as time and motion seem to fall into a broader construct of task complexity, which would seem to have an impact on how a task needs to be trained and whether it can be trained virtually. Certainly, the Motion category is relevant to user interface design, but not all motions may adequately translate to a design prescription.

Worker Functions (Functional Job Analysis)

Functional Job Analysis focuses primarily on the objects with which people work. Tasks can be categorized depending on whether or not they deal primarily with data (e.g., analyzing a spreadsheet), people (e.g., convincing a customer to buy a product) or things (e.g., filling a sandbag). Furthermore, these categories can be further broken down into levels of each type of object. For example tasks involving data can include activities such as comparing two pieces of data to see if they match (low level) to analyzing complex data and drawing meaningful conclusions (high level). There are three main categories, Data, People, and Things. Within categories, levels of activity include synthesis and analysis for Data, negotiating and supervising for People, and operating and handling for Things. Designing a user interface to train these categories much depends on the context of work.

These categories seem to relate primarily to qualitative differences in the nature of tasks and seem to have a direct relationship to the underlying knowledge, skills and abilities that are needed to perform the tasks. The basic levels of Data, People and Things do seem to provide unique characteristics that would likely lend themselves to different design methods.

Task Characteristics

Many of the task classification schema that are available in the literature focus on creating task lists of what a worker does. The next step is to determine how these tasks are used on the job and to quantify their relationship to one another. This is most commonly done by collecting ratings of the importance and frequency of tasks. Furthermore, at least one case study (Jelley, 2007) used cluster analysis to empirically group similar tasks based on multiple criteria. The task characteristics as used on the job are drawn from four sources. They are described as follows, from Brannick, Levine, & Morgeson (2007): Difficulty to Learn, Difficulty to Perform, Time Spent to Complete; from Jelley (2007): Frequency of Performance, Expected Day-One Proficiency, Importance to Overall Job; from Jonassen, Tessmer, & Hannum (1999): Universality within a Given Job, Criticality or Consequences of Inadequate Performance, Standardization of Performance across Workers; and Rose et al (1985): Perishability or how rapidly a worker loses the ability to perform without practice.

Among the task characteristics we identified, difficulty to learn, perishability and criticality seem to be particularly relevant to designing user interfaces that may have unique attributes to consider. These components seem to fall into a broader category that relates to task complexity.

Position Analysis Questionnaire (PAQ)

The Position Analysis Questionnaire is a computer-scored job analysis method. Tasks are rated based upon several categories and subcategories as described in Brannick, Levine, & Morgeson, 2007, or McCormick, Jeanneret, & Mecham, 1989. The PAQ categories are Information Input (e.g., perceptual activities), Mental Processes (use of stored information), Work Output (use of physical devices), Interpersonal Activities (personal contact), Work Situation and Job Context (physical working conditions). The challenge for user interface design is in assuring that the training can transfer from the learning environment to the working environment, so certain high stress, noisy, crowded environments may not easily be captured in an interface to training content.

As with most of the task classification schema focusing on job analysis, many of the elements of the PAQ relate to how tasks are used on the job, rather than how tasks should be or could be trained. Of course this is the intended purpose of job analysis classification schema. However, there are many pieces from the PAQ that could prove relevant to identifying unique task classes that might need to be handled differently by interface designs for training purposes.

Information input and mental processes relate to the way that a person perceives and processes information while performing a task. Often in training, the fidelity of these processes to the actual job is quite important to ensure training transfer. Processes of this nature warrant consideration when grouping tasks and selecting instructional methods and media.

Interpersonal activities relate to the nature and quality of interaction with people. Interactions with people and the nature of those interactions seem to be a characteristic that would uniquely differentiate a group of tasks and have implications for how they should be trained. Some interactions may be mimicked through virtual training, but others may be more open-ended and spontaneous requiring a sophistication not yet available.

Work output is geared primarily toward the physical activities required to perform a task, but also has implications for collective tasks in the "coordination of activities" category. Therefore, work output also worthy of further consideration as one of the criteria to include in our task classification.

Bloom's Taxonomy

Bloom's Taxonomy (1956) was developed to describe and categorize learning. It remains a popular scheme to categorize domains of learning. The domains are cognitive, affective, and psychomotor. Cognitive refers to the acquisition of knowledge and the development of skills, affective refers to tasks the involve emotions, motivation, and attitudes, and psychomotor involves tasks the involve physical movement and refined motor skills.

Additionally, Bloom theorized that learning occurred at different levels of intellectual behaviors. The levels described by Bloom vary along a continuum of complexity with knowledge being the least complex and evaluation being the most complex. The levels are listed in Table 1.

The intellectual behaviors detailed in Table 1 relate to progressively greater levels of cognitive processing. These factors relate to overall task complexity and how difficult it is to learn a task, and would seem to have a relationship with how tasks in these categories would need to be trained, which could impact instructional method and media choices; however, the greater implication of these levels is to the learning methodology and instructional design that should be employed rather than the technology itself.

The cognitive, affective, and psychomotor domains identified by Bloom represent qualitatively different modes of learning. These different modes of learning would seem to require different modes and methods of training, which likely has

Table 1. Bloom's levels of intellectual behaviors

Levels	Examples
Knowledge	Defining, labeling, organizing
Understanding	Describing and explaining
Application	Demonstrating and interpreting
Analysis	Appraising, comparing, criticizing
Synthesis	Composing and developing
Evaluation	Arguing and predicting

implications for media selection and interface design (Reiser & Gagné, 1983)..

Cognitive Task Analysis

This type of analysis examines the cognitive processes associated with the completion of tasks. As a part of that process, tasks can be categorized and compared based upon the types of skills associated with them. Specifically, the skills are grouped into automated, representational, and decision making categories. The categories are presented in Table 2.

Instructional Requirements that Limit Instructional Methods

When training tasks, the instructional activities and conditions must include certain elements in order for the intended skills to be transferred. For example, in a fire emergency, individuals are taught to smell for smoke and feel a door for warmth. These factors may or may not be critical in learning a task. If they are critical and if a interface to a virtual training system cannot successfully replicate these conditions, the likelihood of learning the task is reduced. By the same token, if they are critical, then they must also be replicated in a classroom or field setting. Clark, Bewley, and O'Neil (2006) established a set of three training requirements by which training tasks can be categorized. Sensory mode requirements refer to tasks in which you must taste, touch, or smell something in order to learn the task adequately. If these sensory modes are required to learn a task, they must be present in the training environment. Conditional knowledge requirements address fidelity of a situation. Specifically, if a task takes place in a specific condition (e.g., at night, under water, or high heat), these conditions must be adequately represented in the training environment. Synchronous feedback refers to the ability for training participants to get immediate feedback through the user interface about their actions. This is especially true for complex tasks, during which a coach may be required to stop practice, provide feedback, and demonstrate. The instructional requirements that can limit the use of interfaces include a Sensory Mode Requirement, namely touch, smell, or taste, a Conditional Knowledge

Table 2. Categories of cognitive skills

Category	Description	Example
Automated	Skills that involve little effort or attention	Riding a bicycle
Representational	Skills that involve the use of mental models	Planning a maneuver
Decision Making	The ability to apply general rules and principles to make decisions quickly	Reading channel markers in the water to know if your boat is on course

Requirement, the need for the learning environment of have high fidelity such as gravitational pull for parachute instruction, and a Synchronous Feedback Requirement, the need for immediacy of feedback during training (Clark, Bewley, & O'Neil, 2006).

Level of Interaction

Whether in a classroom setting or through distributed learning, students have multiple levels of interaction in learning any task. Moore (1989) defines three types of interactions in instructional settings: learner-instructor, learner-content, and learner-learner. Each promotes learning, but in classroom environments, the emphasis is traditionally on learner-instructor and learner-content interactions, as knowledge is seen traditionally as flowing towards the learner. More generally, Wagner (1997) defines interactions as reciprocal events requiring two objects and two actions. A feature of effective interactions is that they must result in the transfer of knowledge or a change in intrinsic motivation. In classifying tasks, the breakout of interaction types relate to the 'people level' of worker functions described earlier. Wagner further identifies thirteen types of interactions that can occur in learning environments, presented in Table 3.

More contemporary social constructivist theories of learning, however, point to learner-learner interaction as a key to enhancing learning. In the classroom, these may occur between training sessions or in other ways uncontrollable by the instructor. A challenge for designers of instructional interfaces is how to support such learning. For collective tasks, interactions between learners (i.e., between team members) is central to task execution.

Perishability and Task Retention Models

More than a century of research on memory has shown that large amounts of forgetting can occur naturally over periods as short as several hours or as long as many years. Furthermore, research has shown that memory for continuous (perceptual-motor) skills is different from memory for discrete (procedural) skills. The task of bicycle riding, for example, may last a lifetime, even after years without practice. This is an example of a continuous perceptual-motor skill. Remembering the correct procedure for changing a flat tire on a bicycle, however, can perish since it is a task with discrete, knowledge-dependent procedures. Organizations makes a large investment in training knowledge-dependent procedures, with thousands of tasks fitting into this category. The issue of retaining task knowledge, therefore, is of vital interest in considering a task categorization scheme.

In the 1980s, the U.S. Army Research Institute undertook an effort to organize and integrate many of the retention research findings into an

Table 3. Types of interactions between learners and instructors

Interaction Types	
to increase willingness to engage in learning	for negotiation of understanding
to increase participation	for teambuilding
to develop communication	for discovery
to receive feedback	for exploration
to enhance elaboration and retention	for clarification of understanding
to support learner/self-regulation	for closure
to increase motivation	

instrument for predicting how rapidly individual procedural tasks are forgotten. The result of this effort is the User's Manual for Predicting Military Task Retention (Rose, Czarnolewski, Gragg,, Austin, & Ford, 1985). The manual, which represents a model of skill retention, was designed to guide a trainer or analyst through a process of numerically rating an individual task on key factors just discussed.

The output is a single score that predicts the decline in performance among soldiers who start out fully proficient. It identifies a curve that gives the percentage of soldiers in a unit who will be able to perform the task correctly after a given interval of no practice. Training managers can use the model to answer questions such as:

- How quickly will a particular task be forgotten?
- Among several tasks, which is most likely to be forgotten or remembered after a given interval?
- When should reacquisition training on a particular task be conducted to keep group performance from falling below an acceptable level?

The task retention model was not designed to address the difficulty of learning a task or how to conduct training. It focuses on task characteristics and does not take into account any techniques or strategies used during initial training or during the retention period to counteract forgetting. However, factors identified in this model provide information about task complexity and the ways that tasks vary in terms of how they are forgotten (and perhaps learned as well). The ten task factors considered by the Task Retention Model are: 1) are job aids used; 2) what is the quality of the job aid; 3) how many steps are required; 4) are the steps ordered; 5) is there built in feedback; 6) is there a time limit; 7)what are the mental requirements (e.g., Blooms level of intellectual behavior); 8) how many facts must be memorized; 9) how difficult are the facts, terms to remember (e.g., use of mnemonic devices); 10) are there motor control demands.

Summary of Task Categories

The goal of developing a set of categorization criteria for the training of tasks was to identify discrete categories of tasks that vary in terms of training and learner interface design considerations. Ideally, a task classification system should separate tasks on distinct processes that have implications for the mode of instructional delivery (Sugrue & Clark, 2000), which in turn can influence the interface. Depending on the purpose of training, such as regulatory compliance, safety, product familiarity, future performance, long-term retention, different categorical sets can then contribute to issues in designing a learner interface to training content (Robinson, 2007). There may be no best approach, and just as there is overlap between the schemes there is also uniqueness.

Among the factors identified in our literature review, three stand out as particularly important in the context of learner interface design. First based on the work of Rose et al. (1985) is the Perishability of tasks and the underlying complexity of the task. Issues related to how quickly tasks can be forgotten, how frequently they need to be retrained, and how quickly they can be reacquired are important factors to consider in the design phase. The second criteria from cognitive task analysis is Decision Making. Skills that require Decision Making tend to be complex, which creates specific training challenges. Finally, from the instructional requirements category, the Sensory Mode requirement where the sense of touch, smell or touch are required to perform a task clearly has unique training design considerations. While there are certainly additional criteria that warrant further consideration, these three are addressed in our initial framework presented here.

A FRAMEWORK FOR LEARNER-CENTERED DESIGN AND TRAINING TASK CATEGORIES

This final section attempts to unify elements from the reviews. A notional subset of principles and categories have been arbitrarily selected for further consideration in the framework. There were thousands of possibilities, so we have limited our analysis to a notional set of three principals or categories, identified earlier, from each of three fields of inquiry. This leads to 3 x 3 x 3 or 27 separate configurations to evaluate as having relevance to an interface design to digital content for training that is learner-centered, sensitive to design principles, and focused on a particular category of training. The subset of principles and categories seleted are presented in Table 4.

The analysis of the various configurations was accomplished through a consensus building process of independent rater judgments using three judges with a combined experience of more than 50 years in the field of training analysis. Each of the 27configurations, such as Construction of Knowledge by Versatility by Sensory Mode, were rated as having high, medium, or low relevance for an interface. By this, we mean that high relevance configurations should check against the features of a user design for training content, and the medium and low relevance are less important. The results of this very preliminary analysis are presented below.

High Relevance for Interface Design

- Context of Learning x Familiarity x Sensory Mode
- Context of Learning x Affinity x Sensory Mode
- Construction of Knowledge x Familiarity x Perishability
- Construction of Knowledge x Versatility x Perishability
- Construction of Knowledge x Affinity x Perishability
- Construction of Knowledge x Familiarity x Sensory Mode
- Construction of Knowledge x Versatility x Sensory Mode

Medium Relevance for Interface Design

- Construction of Knowledge x Familiarity x Decision Making
- Construction of Knowledge x Versatility x Decision Making
- Individual Differences x Versatility x Sensory Mode

Table 4. Notional set of considerations for learner-centered training interfaces

Source	Principal or Category
Learner-Centered Psychological	Construction of Knowledge
Learner-Centered Psychological	Context of Learning
Learner-Centered Psychological	Individual Differences
User-Interface	Familiarity
User-Interface	Versatility
User-Interface Training Category	Affinity Perishability (task characteristics)
Training Category	Decision Making (cognitive task analysis)
Training Category	Sensory Mode (instructional reqmts)

- Individual Differences x Familiarity x Perishability
- Individual Differences x Versatility x Perishability
- Individual Differences x Affinity x Perishability
- Context of Learning x Familiarity x Decision Making
- Context of Learning x Affinity x Decision Making
- Context of Learning x Versatility x Decision Making
- Context of Learning x Versatility x Sensory Mode
- Individual Differences x Familiarity x Decision Making
- Construction of Knowledge x Affinity x Decision Making
- Construction of Knowledge x Affinity x Sensory Mode

Low Relevance for Interface Design

- Context of Learning x Familiarity x Perishability
- Context of Learning x Versatility x Perishability
- Context of Learning x Affinity x Perishability
- Individual Differences x Familiarity x Sensory Mode
- Individual Differences x Affinity x Sensory Mode
- Individual Differences x Versatility x Decision Making
- Individual Differences x Affinity x Decision Making

The ratings for these configurations should be applied with caution at this point. Scales need to be developed, rating categories need to be better defined, and outcomes need to be validated. This is the first step in exploring the intricate relationships between designs for training that are learner centered, are sensitive to task categories, and consider traditional guidelines on user interface design.

FUTURE RESEARCH DIRECTIONS

The analysis presented here must be considered preliminary. The notional elements represent but a small subset of the many combinations and the rater judgments have not been validated. Future research should systematically manipulate the elements as independent variables in a variety of experimental settings and consider both the immediate learning outcomes and the longer term retention of the training content as an indicator of learning (Wisher, Curnow & Seidel, 2001). It is possible, for example, that the Versatility of an interface when combined with a Construction of Knowledge element of learner centered principles leads to longer retention. Continuing the example, there may be no differences in immediate learning outcomes, but a significant difference in knowledge retention 90 days later. This is of great importance to training since it is transfer to of performance to other environments that is the key to training success.

Much of the research in online learning has focused on educational rather than training programs. The considerations here may not necessarily apply to educational environments, which are much more open ended. Parallel considerations with a revision from task categories to perhaps Bloom's level of intellectual behaviors presented in Table 1 may be the appropriate way ahead. The challenges and opportunities of this volume's theme, including social and cross-cultural dimensions, are broad and deep. Research and its coordination are needed across many multi-disciplinary areas to fully realize the potential of the learner-as-user interface to digital content.

CONCLUSION

There are many facets to designing user interfaces. Much is driven by the purpose of the interface. Much of the literature on interface design stems from the field of software engineering, based on fundamental user analysis, such as the GOMS model, or how to do a task in terms of Goals, Operators, Methods, and Selection Rules (Card, Moran & Newell, 1983). Much of the focusing was on using rather than learner, although one could obviously employ the interface as a stand-alone traning device. This chapter aimed to capture the many popular views of interface design, learner centered principles, and task categories and examine how they intersect and what that may imply for user interface design.

REFERENCES

Alexander, P., & Murphy, P. K. (1994). *The research base for APA's learner-centered psychological principles*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, Louisiana, USA.

American Psychological Association. (1993). *Learner-centered psychological principles: Guidelines for school reform and restructuring*. Washington, DC: American Psychological Association and the Mid-continent Regional Education Laboratory.

Bandura, A. (1997). *Self efficacy: The exercise of control*. New York, NY: WH Freeman & Company.

Bloom, B. S. (1956). *Taxonomy of educational objectives, handbook I: The cognitive domain*. New York, NY: David McKay, Inc.

Bonk, C. J., & Reynolds, T. H. (1997). Web-based instructional techniques for higher-order thinking, teamwork, and apprenticeship. In Khan, B. H. (Ed.), *Web-based instruction* (pp. 167–178). Ed Tech Pubs.

Bonk, C. J., Wisher, R. A., & Lee, J. (2004). Moderating learner-centered elearning: Problems and solutions, benefits and implications. In Roberts, T. S. (Ed.), *Online collaborative learning: Theory and practice* (pp. 54–85). Hershey, PA: Idea Group Publishing.

Brannick, M. T., Levine, E. L., & Morgeson, F. P. (2007). *Job and work analysis: Methods, research, and applications for human resource management*. Thousand Oaks, CA: Sage Publications.

Card, S., Moran, T., & Newell, A. (1983). *The psychology of human-computer interaction*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Clark, R., & Wittrock, M. C. (2000). Psychological principles of training. In Tobias, S., & Fletcher, J. (Eds.), *Training and retraining: A handbook for business, industry, government, and military* (pp. 51–84). New York, NY: Macmillan Reference USA.

Clark, R. E., Bewley, W. L., & O'Neil, H. F. (2006). Heuristics for selecting distance or classroom settings for courses. In O'Neil, H., & Perez, R. (Eds.), *Web-based learning: Theory, research, and practice*. Mahway, NJ: Lawrence Erlbaum & Associates.

Dahl, Y., Alsos, O. A., & Svanæs, D. (2010). Fidelity consideration for simulation-based usability assessments of mobile ICT for hospitals. *International Journal of Human-Computer Interaction*, *26*, 445–476. doi:10.1080/10447311003719938

Dimock, K., & Boethel, M. (1999). *Constructing knowledge with technology*. Austin, TX: Southwest Education Development Lab.

Goldstein, I. L., & Ford, J. K. (2002). *Training in organizations: Needs assessment, development, and evaluation* (4th ed.). Belmont, CA: Wadsworth Publishing.

Hannafin, M. J., & Land, S. (1997). The foundations and assumptions of technology-enhanced, student-centered learning environments. *Instructional Science*, *25*, 167–202. doi:10.1023/A:1002997414652

Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology*, *90*, 414–434. doi:10.1037/0022-0663.90.3.414

Hays, R. T., Jacobs, J. W., Prince, C., & Salas, E. (1992). Flight simulator effectiveness: A meta-analysis. *Military Psychology*, *4*, 63–74. doi:10.1207/s15327876mp0402_1

Jelley, R. B. (2007). *Police management job analysis and leadership needs assessment.* Unpublished manuscript, Ontario, CA.

Jonassen, D. H., Tessmer, M., & Hannum, W. H. (1999). *Task analysis methods for instructional design*. Mawah, NJ: Lawrence Earlbaum & Associates.

Khan, B. H. (Ed.). (2001). *Web-based training*. Englewood Cliffs, NJ: Educational Technology Publications.

Kozlowski, S. W. J., & DeShon, R. P. (1999, June). *TEAMSim: Examining the development of basic, strategic, and adaptive performance*.

Kozlowski, S. W. J., & DeShon, R. P. (2004). A psychological fidelity approach to simulation-based training: Theory, research, and principles. In Schiflett, S. G., Elliott, L. R., Salas, E., & Coovert, M. D. (Eds.), *Scaled worlds: Development, validation, and applications*. Burlington, VT: Ashgate.

Mania, K., Badariah, S., Coxon, M., & Watten, P. (2010). Cognitive transfer of spatial awareness states from immersive virtual environments to reality. *ACM Transactions on Applied Perception*, *7*, 1–14. doi:10.1145/1670671.1670673

McCormick, E. J., Jeanneret, P. R., & Mecham, R. C. (1989). *Position analysis questionnaire*. Logan, UT: PAQ Services, Inc.

Merrill, D. C., Reiser, B. J., & Merrill, S. K. (1995). Tutoring: Guided learning by doing. *Cognition and Instruction*, *13*, 315–372. doi:10.1207/s1532690xci1303_1

Moore, M. G. (1989). Three types of interaction. *American Journal of Distance Education*, *3*(2), 1–6. doi:10.1080/08923648909526659

Newell, A. (1990). *Unified theories of cognition*. Cambridge, MA: Cambridge University Press.

Nielsen, J. (1999). *Designing Web usability*. Berkeley, CA: Peachpit Press.

Norman, D. A. (1988). *The psychology of everyday things*. New York, NY: Basic Books.

Norman, D. A. (1993). *Things that make us smart*. Reading, MA: Addison-Wesley.

O'Sullivan, C., Dingliana, J., Giang, T., & Kaiser, M. K. (2003). Evaluating the visual fidelity of physically based animations. *Proceedings of the Association for Computing Machinery's Special Interest Group on Computer Graphics and Interactive Techniques*, *22*, 527–536.

Reiser, R. A., & Gagné, R. M. (1983). *Selecting media for instruction*. Englewood Cliffs, NJ: Educational Technology.

Robinson, P. (2007). Criteria for categorizing and sequencing pedagogic tasks. In del Pilar, M., & Mayo, G. (Eds.), *Investigating tasks in formal language learning*. Tonawanda, NY: Multilingual Matters Ltd.

Rohrer, D., & Pashler, H. (2010). Recent research on human learning challenges conventional instructional strategies. *Educational Research*, *39*, 406–412. doi:10.3102/0013189X10374770

Rose, A., Czarnolewski, M., Gragg, F., Austin, S., & Ford, P. (1985). *Acquisition and retention of soldiering skills (Final Report 671)*. Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

Shneiderman, B. (1992). *Designing the user interface - strategies for effective human-computer interaction* (2nd ed.). Reading, MA: Addison-Wesley Publishing Company.

Spiro, R. J., Feltovich, P. J., Jacobson, M. J., & Coulson, R. L. (1992). Cognitive flexibility, constructivism and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. In Duffy, T., & Jonassen, D. (Eds.), *Constructivism and the technology of instruction*. Hillsdale, NJ: Erlbaum.

Stasko, J. (1997). *Design principles*. Retrieved from http://www.cc.gatech.edu/classes/cs6751_97_winter/Topics/design-princ/

Sugrue, B., & Clark, R. E. (2000). Media selection for training. In Tobias, S., & Fletcher, J. D. (Eds.), *Training and retraining: A handbook for business, industry, government, and the military. New York, NY*. Macmillan Reference, USA.

Taylor, F. W. (1911). *The principles of scientific management*. New York, NY: Harper Bros.

Towler, A., Kraiger, K., Sitzmann, T., Van Overberghe, C., Cruz, J., Ronen, E., & Stewart, D. (2008). The seductive details effect in technology-delivered training. *Performance Improvement Quarterly*, *21*, 65–86. doi:10.1002/piq.20023

Van Velsor, E., & Guthrie, V. A. (1998). Feedback intensive programs. In McCauley, C. D., Moxley, R. S., & Van Velsor, E. (Eds.), *The Center for Creative Leadership handbook of leadership development* (pp. 66–105). San Francisco, CA: Jossey-Bass.

Wagner, E. D. (1997). In support of a functional definition of interaction. In Cyrs, T. E. (Ed.), *Teaching and learning at a distance: What it takes to effectively design, deliver and evaluate programs* (pp. 19–26). San Francisco, CA: Jossey Bass. doi:10.1080/08923649409526852

Waldron, S. M., Patrick, J., Duggan, G. B., Banbury, S., & Howes, A. (2008). Designing information fusion for the encoding of visual-spatial information. *Ergonomics*, *51*, 775–797. doi:10.1080/00140130701811933

Wisher, R., & Khan, B. (2010). *Learning on demand: ADL and the future of e-learning*. Washington, DC: ADL Initiative.

Wisher, R. A., Curnow, C. K., & Seidel, R. J. (2001). Knowledge retention as a latent outcome measure in distance learning. *American Journal of Distance Education*, *15*(3), 20–35. doi:10.1080/08923640109527091

ADDITIONAL READING

Alessi, S. M. (1988). Fidelity in the design of instructional simulations. *Journal of Computer-Based Instruction*, *15*, 40–47.

Arthur, W., Bennett, W., Stanush, P., & McNelly, T. (1998). Factors that influence skill decay and retention: A quantitative review and analysis. *Human Performance*, *11*(1), 57–101. doi:10.1207/s15327043hup1101_3

Bonk, C. J., & Dennen, V. P. (1999). Teaching on the Web: With a little help from my pedagogical friends. *Journal of Computing in Higher Education*, *11*(1), 3–28. doi:10.1007/BF02940840

Burgoon, J. K., Bonito, J. A., Bengtsson, B., Cederberg, C., Lundeberg, M., & Allspach, L. (2000). Interactivity in human-computer interaction: A study of credibility, understanding, and influence. *Computers in Human Behavior*, *16*, 553–574. doi:10.1016/S0747-5632(00)00029-7

Colquitt, J. A., LePine, J. A., & Noe, R. A. (2000). Towards integrative theory of training motivation: A meta-analytic path analysis of 20 years of research. *The Journal of Applied Psychology*, *85*, 678–707. doi:10.1037/0021-9010.85.5.678

Dede, C. (2007). Reinventing the Role of Information and Communications Technologies in Education. *Yearbook of the National Society for the Study of Education*, *106*, 11–38. doi:10.1111/j.1744-7984.2007.00113.x

Dodds, P. V. W., & Fletcher, J. D. (2004). Opportunities for new "smart" learning environments enabled by next generation web capabilities. *Journal of Educational Multimedia and Hypermedia*, *13*, 391–404.

Doherty, P. B. (1998). Learner control in asynchronous learning environments. *Asynchronous Learning Networks Magazine*, *2*(2), 1–11.

Ericsson, K. A., & Lehmann, A. C. (1996). Expert and exceptional performance: Evidence of maximal adaptation to task constraints. *Annual Review of Psychology*, *47*, 273–305. doi:10.1146/annurev.psych.47.1.273

Farr, M. (1987). *The long-term retention of knowledge and skills: A cognitive and instructional perspective*. New York: Springer-Verlag.

Fletcher, J. D., & Tobias, S. (2005). The multimedia principle. In R. E, Mayer (Ed.) *The Cambridge Handbook of Multimedia Learning* (pp 117-133). New York, NY: Cambridge University Press.

Graesser, A.C., Person, N., Harter, D., & TRG (2000). Teaching tactics in AutoTutor. *Proceedings of the workshop on modeling human teaching tactics and strategies at the Intelligent Tutoring Systems 2000 conference.* University of Quebec at Montreal, 49-57.

Hall, B. (1997). *Web-based training cookbook*. New York: Wiley & Sons.

Hays, R. T., & Singer, M. J. (1989). *Simulation fidelity in training system design: Bridging the gap between reality and training*. London, England: Springer-Verlag.

Healy, A., & Bourne, L. Jr. (1995). *Learning and memory of knowledge and skills: Durability and specificity*. Thousands Oaks, CA: Sage.

Hellervik, L. W. (1992). Behavior change: Models, methods, and a review of the evidence. In Dunnette, M. D., & Hough, L. M. (Eds.), *Handbook of industrial and organizational psychology* (2nd ed., *Vol. 3*, pp. 821–895). Palo Alto, CA: Consulting Psychologists Press.

Locke, E., & Latham, G. (2002). Building a practically useful theory of goal setting and task motivation. *The American Psychologist*, *57*, 705–717. doi:10.1037/0003-066X.57.9.705

Nardi, B. A. (1996). *Context and Consciousness: Activity Theory and Human-Computer Interaction*. Boston, MA: Massachusetts Institute of Technology.

Nielson, J. (2000). *Designing web usability: The practice of simplicity*. Indianapolis, IN: New Riders Publishing.

Noe, R. A. (2008). *Employee training and development* (4th ed.). New York: Irwin-McGraw.

Northam, G. (2000). *Simulation Fidelity – Getting in Touch with Reality*. Proceedings of the SimTechT annual conference, Sydney, Australia.

Sadasivan, S. (2008). *Effective VR: Interplay of Presence, Perceptions, Fidelity, and Transfer Effects in the Development of Inspection Training Simulators.* Unpublished doctoral dissertation, Clemson, SC.

Schraagen, J. M., Chimpman, S. F., & Shalin, V. L. (2000). *Cognitive Task Analysis*. New York: Routledge Press.

Van Eerde, W., & Thierry, H. (1996). Vroom's expectancy models and work-related criteria: A meta-analysis. *The Journal of Applied Psychology*, *81*, 575–586. doi:10.1037/0021-9010.81.5.575

Wetzel, C. D., Radtke, P. H., & Stern, H. W. (1994). *Review of the effectiveness of video media in instruction*. Hillsdale, NJ: Erlbaum.

KEY TERMS AND DEFINITIONS

Affective: In the context of learning, affective refers to tasks that involve emotions, motivation, and attitudes.

Cognitive: In the context of learning, cognitive refers to the acquisition of knowledge and the development of skills.

Individual Differences: The ways in which individual people differ in their behavior, preferences, and abilities.

Physical Fidelity: The extent to which a simulator realistically reproduces the aspects of the environment in which the actual task will be conducted.

Psychological Fidelity: The extent to which a training environment replicates the psychological processes relevant to the successful completion a task in the actual environment.

Psychomotor: In the context to learning, psychomotor refers to tasks that involve physical movement and refined motor skills.

Training: A systematic set of processes implemented with the goal of helping individuals and groups acquire the skills, rules, concepts, and attitudes that result in improved performance in another environment.