ADVANCES IN LEARNING AND INSTRUCTIONAL DESIGN THEORIES

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ABSTRACT

Learning and instructional design theory is the body of principles proposed by psychologists and educators to explain how people acquire skills, knowledge, and attitudes. Learning theory is used in formal instruction to facilitate and accelerate the learning process. When applied to the practice of instruction, learning principles derived from theories can guide the instructional designer in improving the effectiveness and efficiency of the learning activities of a program. This discussion of learning theory is an attempt to express the human process of learning in terms that can be applied in training and education. The categories of human activity have been delineated by learning theorists. This paper uses those categories to establish a framework for how learning takes place and addresses how learning theory is applied to the selection of instructional strategies as well as the media selected to deliver the instruction. The paper also addresses the fact how, in real life, the various types of learning are integrated. This integration of human activities is discussed in terms of schemas, enterprise theory and metaskills.

ABOUT THE AUTHORS

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INTRODUCTION

The human process of learning is complex. The methods for preparing instruction have grown out of an attempt to understand this complex process. Irrespective of how well instruction agrees with the human process of learning, instruction will continue to take place. People will be taught or they will find out on their own what they need to know and how to do what they need to do in order to meet the demands placed upon them. In the course of events, unforeseen detours will be made, unneeded costs will be expended, and in some cases there will be unnecessary failures. A body of psychologists and educators have attempted to better understand this complex process of human learning and derive methods for improving the effectiveness and efficiency of corresponding instruction.

Categories of Learning

Early attempts to understand the complexities of learning resulted in classifications in categories of learning. Bloom[1] was the first to classify domains of learning (cognitive, affective, and psychomotor. His classifications helped to teach others about learning, but the transition of this taxonomy of learning to instructional design was not realistic. Gagné[2] was able to define a classification which corresponded to learning phases. Gagné's five categories are: intellectual skills, verbal information, cognitive strategies, motor skills, and attitudes. In preparing a classification for educational technology applications, Merrill[3] classified learning domains in the performance-context matrix (remember, use, and find; fact concept, procedure and principle. Reigeluth[4] provided another sort by types of learning including memorization, understanding, skills application, general skills, and affective learning. In general, these types of learning are grouped as psychomotor or behavioral, intellectual or cognitive, and feeling or affective.

Behavioral learning activities can be simple, such as stimulus-response-reinforcement event[5], or more complex, such as riding a bicycle. The behavioral approach in instructional design is to select learning outcomes which demonstrate that the desired learning has taken place, often referred to as the terminal behavior[6]. Behaviors are directly observable and measurable. The application of this approach to instructional design works well with specific tasks that have corresponding terminal behaviors. It is more difficult to apply in more complex goals involving multiple objectives and an understanding of a person's thought process and associated feelings[7].

Cognitive learning activities draw attention to mental process and methods for organizing information or experiences or establishing relationships. Understanding a cognitive approach is more difficult because the activity is unseen and the descriptions are often abstract. Knowledge is not directly observable but it is measurable. The application to instructional design allows another dimension for explaining expected learning outcomes.

The **affective domain** is the emotional context for learning, a dimension for which little theory has been derived. The affective domain, such as attitudes and motivation, is also abstract and internalized. In situations where there is little behavioral feedback and no verbalized response, understanding the affective domain is quite difficult. The application to instructional design is therefore more difficult. There is an understanding that motivation is important and attitude, particularly in critical situations, must be instilled. Making the affective domain a part of instructional design established importance for gaining the attention of the learner, establishing relevance for the learner, and building the learner's confidence in and satisfaction with the instruction[8].

Integration in Application

Categories of learning help us understand the complex process of human learning, but in application the approach is to integrate. Gagné reflected on his categorization of learning types, and apologized for causing the segregation of the categories[9]. He noted that this separation was only to assist in understanding the complexities of learning. He never intended for segregation, but rather integration in application. He said that in reality all the categories play together as a whole. This means in application to instructional design, the approach should be a comprehensive one, incorporating all categories of learning. Gagné and Merrill[7] proposed that such an integration of multiple objectives be conceived in terms of the pursuit of a comprehensive purpose in which the learner is engaged, called enterprise.

COGNITIVE THEORY

More contemporary attempts to define the complex process of human learning are known as cognitive theories. These theories focus on what is going on inside the learner's mind. Two respected models of cognitive theory are the information processing model and the social interaction model.

Information Processing Model

The information processing model says that the learner's brain has internal structures that select and process incoming material, store and retrieve it, use it to produce behavior, and receive and process feedback on the results. A number of cognitive processes are involved in learning, including the "executive" functions of recognizing expectancies, planning and monitoring performance, encoding and chunking information, and producing internal and external responses.

The purpose of instruction is to activate the internal processes in order to facilitate the acquisition of new skills, knowledge and attitudes. Different kinds of learning outcomes require different means for activating the internal processes, and these means are called instructional strategies. Application of the information processing model in instructional design is shown in Table 1. This table shows the relationship between learning processes and phases and provides examples of general instructional design strategies that support learning.

Social Interaction Model

Social interaction theory says that learning and the consequent changes in behavior take place as a result of interaction between the learner and the environment. This environment can facilitate or inhibit learning. A context promoting cooperative learning is more helpful to students than one promoting individual work, especially with regard to learning attitudes. An effective application is when the interaction among students is given support through tutoring and feedback, such as peer tutoring.

Social interaction states that students learn as they confront the response demands built into the activities in which they participate. Good activities are built around the attainment of multiple goals even within a given activity. The application to instructional design is the formation of activities which engage students in active forms of learning. These active forms of learning help develop values as well as critical thinking skills, are built around "important" content, and are well matched to the learner's abilities and interests. The instructional delivery approaches are varied in order to facilitate the attainment of the multiple goals.

INTEGRATION OF HUMAN ACTIVITIES

Cognitive theories help us understand the complexities of human learning. Tennyson[10] notes that, in reality, the cognitive systems are dynamic, they interact, and they are integrated. The relationship of integration in development is depicted by the progress from the apprentice to the novice and then the expert. The apprentice develops to a point of initial proficiency. Integrative goals have been obtained complete to terminal objectives. Achievement of the expected learned capability occurs in the defined condition or environment at the desired standard or level of activity. An assessment is made that the integrative goals have been reached. The performance is now that of the novice, able to do the job but still needing"aging and experiencing." From novice, development continues over time. Skills become more robust, ability to adapt among variations is expanded, choices leading to solutions are more appropriate

Table 1. Application of Information Processing Model in Instructional Design

Learning Process	Learning Phase	Instructional Aim	Strategies to Support the Processes	Examples
Expectancy	Motivation	Build relevancy and communicate the goal	• Set the stage • Personalize the context • Create uncertainty	• Tell a story • Provide a demonstration • Ask leading questions
Perception	Apprehending	Focus attention	• Use novel or interesting examples • Activate the learner's senses	• Use color • Use print techniques such as bold face type or italics • Introduce sounds, smells, real objects, video
Working Storage	Acquisition	Present information in manageable units	• Organize the content • Produce a visual image that illustrates abstract information	• Use mnemonics • Chunk information • Outline information • Use imaging techniques (such as concept mapping and Information Mapping®)
Encoding	Processing	Build upon existing knowledge	• Put content into meaningful context	• Provide analogy, metaphor, simile • Provide meaningful examples and nonexamples
Storage	Retention	Merge new information with existing knowledge	• Encourage rehearsal • Provide for spaced review	• Create new examples • Paraphrase information • Have learner verbalize new SKA
Retrieval	Recall	Attach the new skill, knowledge, attitude (SKA) to environmental cues	• Provide situations in which new information should be used	• Practice applications of new SKA • Have learner teach new SKA
Validation of Understanding	Feedback	Test accuracy of new SKA	• Compare performance to acceptable standard	• Provide feedback to learner
Transfer	Generalization	Allow for generalization of recall cues	• Provide collaborative learning exercises (team problem solving) • Provide alternative contexts in which SKA can be used	• Illustrate how new SKA might be used in new situation • Have learners generate new ways to use SKA
Valuing	Personalizing	Reinforce meaningfulness of new SKA	• Utilize SKA as context for new learning • Apply SKA in authentic activities	• Reinforce behavior by making it relevant to work or another new SKA to be learned

Source: AFMAN 36-2234, Instructional System Development[11] and precise, and an elaborate method for simultaneous learning begins. An expert begins to emerge.

Fishburne et al.[12] noted that integration is such a complex process that training efficiency, if not effectiveness, could surely be improved if conditions fostering integration are identified and exploited during instruction. Useful terms in discussing integration are schemas, enterprise theory, and metaskills.

Schemas

Information is integrated into existing contexts or related knowledge to be remembered and recalled. This ordering in memory is thought of as schemas or elements representing a large set of meaningful information pertaining to a general concept. The concept may be of an object, such as a jet aircraft, a building, or a tree. Or it may be an event, such as preflight check or lightning strike. Regardless of type, schemas contain information on certain well understood features of the object or event. These features, called slots, are filled in by the learner when encountering new information that relates to the schema. Schemas are acquired through experience and may be the greatest benefit of apprenticeships. The application of schemas in instructional design is that a knowledge or skill should be learned and practiced in context of the "big picture" or broader, more encompassing concept, such as teaching the relationship between the electrical system and starting the engine.

Fishburne et al.[12] described a possible schema structure which would show patterns, relationships, situations and circumstances, similar schemas, approach, attention required, subgoals or checkpoints, rules, context, and dynamic patterns (timing, coordination, variation, cause-effect factors.) Again, this illustrates the complexity of learning. The formulation of schemas takes place within an enterprise.

Enterprise Theory

Gagné and Merrill[7] proposed a method to identify learning goals that require an integration of multiple objectives. They proposed that such an integration of multiple objectives be conceived in terms of the pursuit of a comprehensive purpose in which the learner is engaged, called **enterprise**. An enterprise is a purposeful, planned activity that may depend for its execution on some combination of verbal information, intellectual skills, and cognitive strategies, all related by their involvement in the common goal. A task for the instructional designer is to identify the goal of a targeted enterprise along with its component skills, knowledge, and attitudes, and then to design instruction that enable the student to acquire the capability of achieving this integrated outcome.

Accomplishment of schemas is an enterprise. The student works to a goal, and wants to achieve. *Relationships between enterprises begin* in part-task training, with normal procedures, simple activities, proficiency advancement, establishing relationships of part-to-whole. Building learning-on-learning, enterprises become more complex, variations such as emergency procedures are introduced, coordination among other players is practiced. Over time, broad expertise is developed as experience and confidence increase.

Relationships between enterprises begin in part-task training, starting first with normal procedures. The initial enterprises are simplified goals with proficiency required before proceeding to the next enterprise. Relationships are established part-to-whole and practice begins in integrating related enterprises. Through this process, learning is built upon learning and enterprises become more complex. Variations are introduced such as emergency procedures and interactions required with other players. The resulting complex enterprise performed proficiently under varying conditions must be organized in a manner that can be described in terms of hierarchical relationships. This is a macro approach to understanding enterprise components and the strategies for accomplishing them.

A good approach to understanding what must happen during successful development is to focus on the differences between the schemas in novices and those of experts. For example, in aircrew training there is a point called acquisition of initial proficiency where the new pilot can accomplish all the checklist items and perform the maneuvers correctly. There the integrated performance is that of the novice. The instructor recognizes that the right schemas for safe flight are formed, but the novice must continue to work other enterprises in order to gain"age and experience." The pilot continues from initial qualification to mission or combat qualification. The schemas are now expanded to meet the demands of the "real world." The squadron commander knows that this is not enough. Exercises such as Red Flag, combat training in simulation, in-flight practice in multiple situation, each build on the schemas. In time the expert emerges, having achieved a repertoire of metaskills.

Figure 1 shows the progression from simple individual objectives to the more complex end goal or terminal objective. The integration of multiple objectives, or enterprises, is developed along the simple to complex continuum. The highest plateau of this continuum is the metaskill. Fishburne et al.[12] described the metaskill as the ability to adapt the specific skills it affects to the requirements of a situation. It is the essence of skill robustness. The more generalized the metaskill, the greater the variations among situations that can be accommodated; the more the metaskill is simultaneously discriminative, the more likely that given adaptations will be appropriate and precise. Metaskills thus serve as a high-level transfer system. The performer draws upon past experience to define and structure situation requirements and adapt skills accordingly. Fully developed, they are elaborate systems for simultaneous learning. In other words, the expert has metaskills.

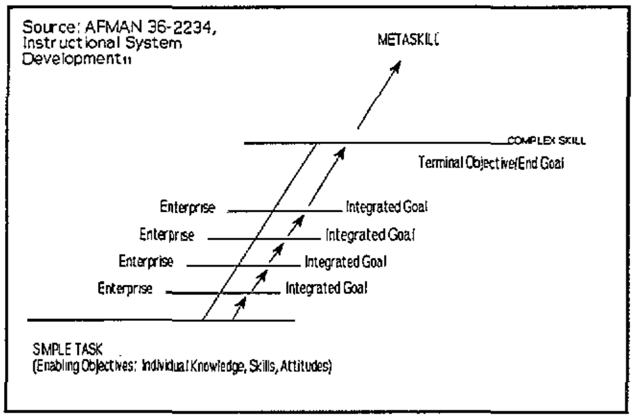

Figure 1. Progression from Simple Task to Metaskill

Metaskill

Spears[13] described a metaskill as the complex skill of adapting, monitoring, and correcting the use of individual skills in complex performances that integrate all learning processes. The person with a metaskill can deal with the novel situation successfully.

Media Selection for Integrated Activities

Gibbons[14] describes the method of media selection for integrated activities. Table 2 summarizes the approaches to consider when selecting media for integrated learning activities. Examples of learning activities for each approach are provided with possible media for supporting those activities. The instructional designer should consider the learning activity for which instruction is being prepared and select the appropriate media to achieve the integrated goal, end goal, or terminal objective.

Assessment of Integrated Activities

The method for assessing integrated activities is in context of the activity or event, such as low visibility takeoff or riding a bicycle in traffic. One approach is to use the degree of instructor involvement with the student. The 7-point scale starts with the student observing and the instructor demonstrating (1.0) and goes in half-point increments to the student performing beyond mere proficiency with no instructor intervention (4.0). Another approach is to use the degree of performance observed. This 4-point scale starts with performance that indicates lack of ability and knowledge (1) and goes to performance with unusually high degree of ability (4). Whatever the approach, a rating from the scale is given for each event accomplished during the training session. The form for recording the responses has the rating scale defined across the top of the form and the flight events listed by phase of flight down the side. There is a block next to each event for the rating and a space to the right for any notes the instructor feels important to jot down. This method has been used successfully for grading student progress in both simulation and inflight aircrew training.

Data from student ratings is a good measure for training effectiveness evaluation. Experience in using this data has shown that data should be summarized only by event. There is important understanding between events that is masked if an attempt is made to average ratings across events. The training decisions are also made event by event, such as when the benefit of training an event in simulation has been achieved and the remainder of training needs to be in the aircraft.

Table 2. Approaches for Media Selection for Integrated Learning Activities

Approach	Example of Activity	Example of Media
Provide alternate media for presentation and practice	Function of Parts	CBT
	Procedures	PTT or Simulator
Provide multiple media for the same task	Emergency Procedures	Classroom, CBT, Simulator
Provide intermediate practice exercises	Air Refueling	PTT, Simulator, Aircraft
Provide repeated, spaced practice	Landing an Aircraft	Simulator, Aircraft

Source: AFMAN 36-2234, Instructional System Development[11]

SUMMARY

The human process of learning is complex and is integrated in real life. The classification schemes and learning theories help us to understand the complex process, but the application to instructional design requires an integrated approach. We can decompose activities into skills, knowledge, and attitudes, and we can list tasks and missions. We can derive corresponding objectives for achievement of each task and define terminal objectives. However, we must not overlook the re-integration of these elements back into the "whole." We build hierarchical relationships, form enterprises of multiple objectives and establish instructional strategies. We always keep in context the "big picture," keeping the student in tune with "how it all fits." We plan beyond initial skill acquisition, preparing for the full life cycle of education and training requirements. We design for metaskill development over the long term. We recognize that the complexities of learning coupled with individual differences cause us to be flexible, willing to adjust to the needs of the moment, We admit today we still do not have all the answers for tomorrow. We will continue to seek a better way.

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