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14

Prescriptive Principles for Instructional Design

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ABSTRACT

This chapter reviews some of the prescriptive principles that, based on research or experience, have been identified for facilitating effective, efficient, and engaging instruction. For the purposes of this chapter, *instruction* is defined as a deliberate attempt to design a product or environment that facilitates the acquisition of specified learning goals. This chapter first reviews the *first principles of instruction* identified by Merrill (2002a). In the second section, recent specifications of instructional design principles are compared to these first principles. The final section reviews approaches for designing instruction centered in whole tasks.

KEYWORDS

4C/ID: Four-component instructional design model (van Merriënboer, 1997).
Activation principle: Learning is promoted when learners activate relevant cognitive structures.
Application principle: Learning is promoted when learners engage in application of their newly acquired knowledge or skill.
Cognitive training model: A five-task instructional design model (Foshay et al., 2003).
Cycle of instruction: The activation–demonstration–application–integration cycle of the first principles.
Demonstration principle: Learning is promoted when learners observe a demonstration of the skills to be learned.
e-Learning principles: Prescriptive principles for designing e-learning; see multimedia learning principles.
First principles of instruction: Five principles fundamental to effective, efficient, and engaging learning.
Instructional design: Creating blueprints for effective, efficient, and engaging instruction.
Integration principle: Learning is promoted when learners integrate their new knowledge into their everyday life.
Minimalist principles: Instructional design principles for sparse instruction.
Multimedia learning principles: Likely effects of text, animation, audio, and graphics on learning.
Pebble-in-the-Pond instructional design: A content-first approach to designing instruction.
Problem-centered instruction: See task-centered instruction principle and strategy.
Scaled instructional strategies: Hypothesis that application of the first principles has an accumulating performance effect for complex skills.
Structure–guidance–coaching–reflection cycle: Instructional assistance within the activation–demonstration–application–reflection cycle of instruction.
Task-centered instruction principle: The central principle that learning is promoted when learners are engaged in a task-centered approach.
Task-centered instructional strategy: Teaching component skills in the context of a progression of real-world whole tasks.
Topic-centered instructional strategy: Teaching component skills in sequence prior to their application to a whole task.

FIRST PRINCIPLES OF INSTRUCTION

Merrill reviewed a number of instructional design theories and models (Dijkstra et al., 1997; Gagné, 1985; Glaser, 1992; Marzano et al., 2001; McCarthy, 1996; Reigeluth, 1983, 1987, 1999; Reigeluth and Carr-Chellman, in press; Tennyson et al., 1997; van Merriënboer, 1997) in an attempt to identify underlying prescriptive principles common to all or most of these approaches. He concluded that they do share common principles and that they do not incorporate fundamentally different principles Merrill (2002a,b; 2006a,b; 2007; in press a,b). These *first principles* are:

- *Task-centered approach*—Learning is promoted when learners are engaged in a task-centered approach, which includes demonstration and application of component skills. A task-centered approach is enhanced when learners undertake a progression of whole tasks.
- *Activation principle*—Learning is promoted when learners activate relevant cognitive structures by being directed to recall, describe, or demonstrate relevant prior knowledge or experience. Activation is enhanced when learners recall or acquire a structure for organizing the new knowledge.
- *Demonstration principle*—Learning is promoted when learners observe a demonstration of the skills to be learned that is consistent with the type of content being taught. Demonstrations are enhanced when learners receive guidance that relates instances to generalities. Demonstrations are enhanced when learners observe media relevant to the content.
- *Application principle*—Learning is promoted when learners engage in the application of

their newly acquired knowledge or skill that is consistent with the type of content being taught. Application is effective only when learners receive intrinsic or corrective feedback. Application is enhanced when learners are coached and when this coaching is gradually withdrawn for each subsequent task.
- *Integration principle*—Learning is promoted when learners integrate their new knowledge into their everyday life by being directed to reflect on, discuss, or defend their new knowledge or skill. Integration is enhanced when learners create, invent, or extrapolate personal ways to use their new knowledge or skill to situations in their world. Integration is enhanced when learners publicly demonstrate their new knowledge or skill.

In this chapter, we summarize some recent presentations of prescriptive principles and compare them to the first principles identified by Merrill. Here, a *prescriptive principle* is a relationship that is always true under appropriate conditions regardless of program or practice. A *practice* is a specific instructional activity. A *program* is a set of prescribed practices. The principles identified in this chapter are underlying relationships rather than alternative instructional models. A given practice, program, or model always implements or fails to implement underlying principles, whether or not these principles are specified. These same principles can be implemented by a wide variety of programs and practices. The principles identified in this chapter share the following properties: First, learning from a given program will be facilitated in direct proportion to its implementation of these principles. Second, these principles of instruction can be implemented in any delivery system or using any instructional architecture (Clark, 2003). Third, these principles of instruction are design oriented rather than learning oriented. They relate to creating learning environments and products rather than describing how learners acquire knowledge and skill from these environments or products.

Our premise is that these design principles apply regardless of the instructional program or practices prescribed by a given theory or model. If this premise is true, research will demonstrate that, when a given instructional program or practice violates or fails to implement one or more of these underlying principles, there will be a decrement in learning and performance.

Elaboration of First Principles

These principles are familiar to many instructional designers and educators. They have been stated in one form or another for at least the past 200 years. Clark (1999) indicated that J. F. Herbart's (1776–1841) followers designed a five-step teaching method that is remarkably similar to the first principles described earlier:

- Prepare the pupils to be ready for the new lesson (activation).
- Present the new lesson (presentation).
- Associate the new lesson with ideas studied earlier (activation, guidance, and coaching).
- Use examples to illustrate the lesson's major points (demonstration).
- Test pupils to ensure they have learned the new lesson (application).

Even though these principles seem to have been available for some time, they are not often used in instructional materials. An extensive survey of 1400 online courses in marriage relationships from five countries demonstrated that most of the instructional programs reviewed failed to implement even one of these principles (Barclay et al., 2004).

Four-Phase Cycle of Instruction

The identification of the first principles does more than merely collect a set of prescriptive principles that might be used to select or design effective instruction. These principles are interrelated to one another. The four-phase cycle of instruction consists of activation, demonstration, application, and integration. Effective instruction involves all four of these activities repeated as required for different problems or whole tasks. A similar four-phase cycle (4-MAT) of instruction consisting of meaning (activation), conceptualizing (demonstration), operationalizing (application), and renewing (integration) was described by McCarthy (1996). The Vanderbilt group described a learning cycle consisting of a set of challenges (task or problem), the generation of ideas (activation), multiple perspectives (demonstration), research and revision (demonstration/application), testing your mettle (application), going public (integration), and looking ahead and reflecting back (integration) (Schwartz et al., 1999).

Problem-Centered Instruction

Perhaps the most important notion of the first principles is that engaging instruction is problem centered; that is, individual instructional components are most effectively taught in the context of a progression of real-world problems where the student is shown a problem, then taught the components, and then shown how the components are used to solve the problem or do the whole task. Van Merriënboer's 4C/ID model for training complex learning tasks makes a very strong research-based argument for centering instruction in whole real-world tasks and then teaching component knowledge and skill in the context of these tasks (van Merriënboer, 1997; van Merriënboer and Kirschner, 2007).

The first principles and 4C/ID identify a task-centered approach that combines the solving of problems with more direct instruction of problem components as contrasted with problem-based approaches in which students are placed in collaborative groups, given resources and a problem, and left to construct their own solution for the problem. Research supports this guided instruction approach over more pure learner-centered approaches with less guidance. Klahr and Nigam (2004) compared guided direct instruction with a discovery learning approach for children learning about confounding variables in scientific experiments. The children were actively involved in performing experiments. The direct instruction group observed demonstration experiments (demonstration–guidance), whereas the discovery group did their own experiments. Klahr and Nigam (2004, p. 661) demonstrated that "many more children learned from direct instruction than from discovery learning" and that children in the direct instruction group made broader and richer scientific judgments about science-fair posters than those in the discovery group. Two important research reviews have argued that instruction involving minimal guidance including problem-based teaching does not work, whereas task-centered approaches involving guidance and coaching are more effective (Kirschner et al., 2006; Mayer, 2004).

Levels of Instructional Strategies

Previous papers (Merrill, 2006a,b) emphasized that the first principles promote enhanced performance on complex tasks. To assess the affects of the first principles it is necessary to assess learners' scaled performance on these complex tasks. Some methods for determining level of performance include: (1) the number of tasks completed in a progression of subsequently more difficult tasks, (2) the amount of coaching required for satisfactory performance on difficult tasks, and (3) the number of stages performed satisfactorily in a nested complex task.

Merrill (2006a) further suggests scaled instructional strategies based on the first principles. He labeled information-only as a level 0 instructional strategy and suggested a series of yet-to-be-tested hypotheses for scaled strategies: (1) A level 1 instructional strategy that adds consistent demonstration to a level 0 information-only strategy promotes a higher performance level on scaled complex tasks. (2) A level 2 instructional strategy that adds consistent application with corrective feedback to a level 1 instructional strategy consisting of information plus demonstration promotes an additional level of performance on complex real-world tasks. (3) A level 3 instructional strategy that consists of a task-centered instructional strategy that includes consistent demonstration and consistent application with corrective feedback promotes an additional increment in the level of performance on complex tasks. (4) Providing or recalling relevant experience promotes an additional increment in learning efficiency, effectiveness, and engagement when added to a level 1, level 2, or level 3 instructional strategies. (5) Providing activation–structure promotes an additional increment in learning efficiency, effectiveness, and engagement when added to level 1, level 2, or level 3 instructional strategies. (6) Adding reflection–integration to any of the above instructional strategies promotes an additional increment in learning efficiency, effectiveness, and engagement. (7) Adding create–integrate to any of the above instructional strategies promotes transfer of the newly acquired knowledge and skill to performance on similar tasks in the real world beyond the instructional situation.

Structure–Guidance–Coaching–Reflection Cycle

Based on a meta-analysis of research on instruction, Marzano and colleagues (2001, p. 32) stated that: "In general, research has demonstrated that making students aware of specific structures in information helps them summarize that information [and subsequently be able to use this information more effectively]" (see also Marzano, 1998). Rosenshine (1997) indicated that when students organize information, summarize information, and compare old material to new material these activities require processing that strengthens cognitive structures and helps students develop more appropriate mental models. These findings suggest that during activation students should be provided or helped to develop a structure for organizing the to-be-learned information. During the demonstration phase, guidance should help the students relate the new information to this structure. During the application phase coaching should help students use this structure to complete the task. During the integration phase, reflection helps students to incorporate this structure into their mental model for subsequent application.

Applications of the First Principles

The authors are aware of several attempts to use versions of this approach for the development of instructional materials. In consultation with M.D. Merrill, Thompson/NETg applied a version of this approach to the revision of their course for Excel (Thomson, 2002). The resulting scenario-based course taught Excel commands in the context of five spreadsheet problems. The test was to prepare three additional spreadsheet tasks without using the help system in Excel. Thompson/NETg undertook a study to validate the first principles of instruction and the Pebble-in-the-Pond model for instructional development. Their development group, with consultation from Merrill, developed scenarios for a course in Excel. They then developed a strategy of problem–progression–component–instruction with guidance for teaching this course as prescribed by the first principles and Pebble-in-the-Pond. The investigators selected study participants from among NETg customers who volunteered to participate in the study.

The customers were divided into three groups: Group 1, the scenario group ($n = 49$), received instruction as prescribed by the first principles. Group 2, the straight e-learning group ($n = 49$), received the existing commercial version of the NETg Excel course. This commercial version of the course systematically teaches all of the commands and operations of Excel using a guided demonstration that instructs learners to execute a command or series of commands and then to observe the consequence of their action on the screen. This same instruction was used for the component instruction in the scenario group. Both groups had access to the same guided demonstration instruction of individual Excel commands. Group 3, a control group ($n = 30$), received the final three authentic scenarios without any prior instruction in Excel. The instruction was delivered online from a company website that also provided frequently asked questions and access to an online mentor for both experimental groups.

On the three authentic tasks, the scenario group scored an average of 89%, the guided demonstration group scored 68%, and the control group scored 34%. All differences are statistically significant beyond the .001 level. Further, the mean times required to complete the three authentic tasks were 29 minutes for the scenario group and 49 minutes for the guided demonstration group. Most of the control group failed to finish the tasks so no time data were recorded. These differences are also statistically significant beyond the .001 level. Finally, on a qualitative questionnaire, the scenario group expressed considerably more satisfaction with the course than did the guided demonstration group.

The first principles formed the basis of a tool used by Shell EP to evaluate and redesign their courses (Collis and Margaryan, 2005, 2007; Margaryan, 2006). Their instrument was applied to over 65 courses that were redesigned to be in greater compliance with the first principles. Twelve courses were studied in detail. The course-scan values (score on the first principles plus) were compared with participant evaluation data and instructors' reflections. The findings indicate that both the students and the instructors felt that the work-based model increased the business relevance of the courses, led to deeper learning processes and more effective performance, and enabled more immediate application of the content to their jobs (Margaryan, 2006).

An entrepreneur course for distance delivery to students in developing countries was developed at Brigham Young University–Hawaii using the first principles and Pebble-in-the-Pond (Mendenhall et al., 2006a,b). Six principles for starting a business were taught in the context of five small businesses. A final exam required evaluating a business plan for a sixth small business. A pilot study compared performance on this exam by 8 business majors who had completed several previous business courses to 12 non-business majors who had completed only this one new course. Of the 12 non-business majors, 7 scored as well as the business majors. At this writing, further development and evaluation of the course are in progress.

Frick et al. (2007) administered an instructor evaluation form that included items that allowed students to report the extent to which the first principles were implemented in numerous courses at multiple institutions. These items were then correlated with student self-report of academic learning time, learning achievement, and learner satisfaction. Preliminary results showed that the use of the first principles in a course is highly correlated with academic learning time (Spearman's $\rho = 0.682$, $p < .0005$, $n = 111$), self-reported student learning achievement ($\rho = 0.823$, $p < .0005$, $n = 110$), and student satisfaction ($\rho = 0.830$, $p < .0005$, $n = 112$). The internal consistency reliability of the first principles scale was 0.941 (Cronbach's alpha). Frick suggests that the inclusion of the first principles in instructor evaluations would increase the ability of such instruments to assess instructional quality.

OTHER INSTRUCTIONAL DESIGN PRINCIPLES

Some recent prescriptive books on designing effective instruction have stated prescriptive principles for instructional design. Merrill (2007) presented a

TABLE 14.1
Clark and Mayer's Principles for e-Learning Aligned with Merrill's First Principles

E-Learning Principles (Clark and Mayer, 2003)	First Principles (Merrill, 2002)
Interactions should mirror the job (p. 153).	Task-centered
Critical tasks require more [distributed] practice (p. 159).	Task-centered–progression
Use job contexts to teach problem-solving processes (p. 251).	Task-centered
Incorporate job-specific problem-solving processes (p. 264).	Task-centered
Use job-realistic or varied worked examples (p. 186).	Task-centered Demonstration
Replace some practice problems with worked examples (p. 177).	Demonstration–guidance
Apply the media elements principles to examples (p. 179).	Demonstration–media
Apply the media elements principles to practice exercises (p. 164).	Application
Train learners to self-question during receptive e-lessons (p. 166).	Integration–reflect
Teach learners to self-explain examples (p. 190).	Integration–reflect
Make learners aware of their problem-solving processes (p. 260).	Integration–reflect
Focus training on thinking processes vs. job knowledge (p. 256).	Integration–extrapolate

synthesis of some of these sources as they relate to the first principles of instruction. The following summarizes some of the principles identified by other authors and attempts to relate them to the first principles of instructional design.

Principles for Multimedia Learning

Based on extensive research, Clark and Mayer (Clark and Mayer, 2003; Mayer, 2001) have identified principles for multimedia learning. These principles elaborate the demonstration principle for relevant media (Mayer, 2001):

- Students learn better from words and pictures than from words alone (p. 63).
- Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen (p. 81).
- Students learn better when corresponding words and pictures are presented simultaneously rather than successively (p. 96).
- Students learn better when extraneous material is excluded rather than included (p. 113).
- Students learn better from animation and narration than from animation and on-screen text (p. 134).
- Students learn better from animation and narration than from animation and narration and text (p. 147).
- Design effects are stronger for low-knowledge learners than for high-knowledge learners and for high-spatial learners rather than low-spatial learners (p. 161).

Principles for e-Learning

In addition to the multimedia principles Clark and Mayer (2003) recommend additional instructional principles (Table 14.1). Correspondence to the first principles is indicated in the right column for each of these principles. It should be evident to the reader that some of these principles have a close correspondence, some of these principles provide more elaboration than the first principles, and some are not included in the first principles. They include personalization, collaboration, and learner-control principles; the first principles do not include principles related to implementation of instruction, such as personalization, collaboration, learner control, and navigation. Perhaps they should. Allen (2003) identified some effective principles for e-learning in three major categories: learner motivation, navigation, and instructional interactivity. Table 14.2 summarizes his keys for motivating e-learning and his checklist for good instructional interactions.

Minimalist Principles

Van der Meij (1998) identified heuristics for designing minimalist instruction (Table 14.3). The task-centered orientation of these heuristics is apparent. Some of these demonstration, application, guidance, and coaching heuristics provide more specific prescriptions than the first principles.

Cognitive Training Model

Foshay et al. (2003) presented a cognitive training model that identifies five tasks learners have to complete when learning: (1) select the information to attend to,

TABLE 14.2
Allen's e-Learning Principles Aligned with Merrill's First Principles

e-Learning Principles (Allen, 2003)	First Principles (Merrill, 2002)
Have the learner perform multistep tasks; having people attempt real (or "authentic") tasks is much more interesting than having them repeat or mimic one step at a time (p. 209).	Task-centered
The learner must apply genuine, authentic skills and knowledge; activities should be as similar to the necessary on-the-job performance as possible (p. 276).	Task-centered
Good interactions are purposeful in the mind of the learner; learners understand what they can accomplish through participation in the interaction (p. 276).	Task-centered Activation
Build on anticipated outcomes; help learners see how their involvement in the e-learning will produce outcomes they care about (p. 158).	Activation (show the whole problem)
Select the right content for each learner; if it is meaningless or learners already know it, it is not going to be an enjoyable learning experience (p. 179).	Activation–prior knowledge
Use an appealing context; novelty, suspense, fascinating graphics, humor, sound, music, and animation all draw learners in when done well (p. 193).[a]	Demonstration–media
Provide intrinsic feedback: Seeing the positive consequences of good performance is better feedback than being told, "Yes, that was good" (p. 214); the feedback demonstrates to learners the ineffectiveness (even risks) of poor responses and the value of good responses (p. 276).	Application–intrinsic feedback
Delay judgment; if learners have to wait for confirmation, they will typically reevaluate for themselves while the tension mounts—essentially reviewing and rehearsing (p. 220).	Application–feedback
Put learners at risk; if learners have something to lose they pay attention (p. 169).	Integration–publicly demonstrate

[a] When implementing this guideline one would do well to remember Mayer's (2001) multimedia principles.

TABLE 14.3
Minimalist Instruction and Merrill's First Principles

Minimalist Principles (van Meij, 1998)	First Principles (Merrill, 2002)
Provide an immediate opportunity to act (p. 22).	Task-centered
Select or design instructional activities that are real tasks (p. 29).	Task-centered
Be sure the components of the task reflect the task structure (p. 31).	Task-centered–components
Prevent mistakes whenever possible (p. 35).	Demonstration–guidance
Provide error information that supports detection, diagnosis, and recovery (p. 38).	Demonstration–guidance
Be brief; do not spell out everything (p. 43).	Demonstration
Provide closure for chapters (p. 44).	Guidance and coaching
Respect the integrity of the user's activity (p. 25).	Application
Provide on-the-spot error information (p. 41).	Application–coaching
Provide error information when actions are error prone or when correction is difficult (p. 37).	Application–coaching
Encourage and support exploration and innovation (p. 23).	Integration–reflect, extrapolate

(2) link the new information with existing knowledge, (3) organize the information, (4) assimilate the new knowledge into existing knowledge, and (5) strengthen the new knowledge in memory. In association with these tasks, they identify 17 elements (prescriptive principles for design) of a training lesson (Table 14.4).

Instructional Principles Based on Learning Principles

Seidel et al. (2004) identified factors influencing the acquisition and transfer of learning as empirically established in the learning literature. From these learning principles they derived guidelines for more effective instructional design. They organized their principles around four domains: the cognitive domain, the affective domain, the psychomotor domain, and the interpersonal domain. Table 14.5 summarizes their design guidelines for the cognitive domain.

4C/ID Instructional Design

Perhaps the most complete recent presentation of instructional strategies is the work of van Merriënboer (1997; van Merriënboer and Kirschner, 2007). The model presents an analysis and design approach that

TABLE 14.4
The Cognitive Training Model and Merrill's First Principles

Cognitive Training Model Principles (Foshay et al., 2003, p. 29)	First Principles (Merrill, 2002)
Answer the question "What's in it for me?" for the learners.	Task-centered (show the task to be completed)
Specify both the desired behavior and the knowledge to be learned.	Task-centered (they are more accepting of traditional objectives)
Gain and focus learners' attention on the new knowledge.	Activation
Bring to the forefront the prerequisite existing (old) knowledge that forms the base on which the new knowledge is built.	Activation–prior knowledge
Organize text presentation to help learners organize new knowledge.	Activation–structure
Tell the learners "You can do it!" regarding learning new knowledge.	Activation (not included in first principles)
Demonstrate real-life examples of how the new knowledge works when it is applied.	Task-centered Demonstration
Organize and limit the amount of new knowledge presented to match human information processing capacity.	Demonstration
Use well-designed illustrations to assist learners' organization and assimilation of new knowledge.	Demonstration
Using a different approach for each type of knowledge, present the new knowledge in a way that makes it easiest to understand.	Demonstration–consistency (see Gagné, 1985; Merrill, 1994)
Involve learners by having them do something with the new knowledge.	Application
Let learners know how well they have done in using the new knowledge, what problems they're having, and why.	Application–feedback (could be both intrinsic and extrinsic)
Present the structure of the content again, including the entire structure of knowledge.	Activation–structure with demonstration guidance
Have the learners use the new knowledge again, this time to prove to themselves, you, and their employer that they have met the objectives of the training.	Application
Have learners use new knowledge in a structured way on the job to ensure they "use it, not lose it."	Integration–extrapolate

TABLE 14.5
Instructional Principles for the Cognitive Domain and Merrill's First Principles

Instructional Principles (Seidel et al., 2004, p. 24)	First Principles (Merrill, 2002)
Provide multiple context environments to facilitate positive transfer within and across domains.	Task-centered–progression of tasks
Use advanced organizers to facilitate integrative skill acquisition and capitalize on prior knowledge.	Activation–structure (coupled with the structure–guidance–coaching–reflection cycle)
Apply the operant principles of minimizing errors, using small steps, and providing immediate reinforcement for acquisition of initial elements of domain knowledge.	Demonstration–consistency (especially for acquiring information)
Use part-task training to break up complex tasks into manageable chunks.	Task-centered Demonstration–component skills

encompass all of the first principles of instruction.* 4C/ID identifies four layers of activity in the instructional development process: (1) principled skill decomposition, (2) analysis of constituent skills and related knowledge, (3) selection of instructional methods, and (4) development of a learning strategy. The first principles have little to say about decomposing a complex skill into a hierarchy of constituent skills; however, the analysis of these constituent skills in 4C/ID is similar to the analysis of a problem to identify the component knowledge and skill for a given task (see Figure 14.1). "At the heart of this training method is whole-task practice, in which more and more complex versions of the whole complex cognitive skill are practiced" (progression of whole tasks) (van Merriënboer, 1997, p. 8). The constituent skills required for

* 4C/ID is an integrated approach for which individual prescriptive statements are difficult to isolate. We have tried to summarize key aspects of this model and relate them to the first principles.

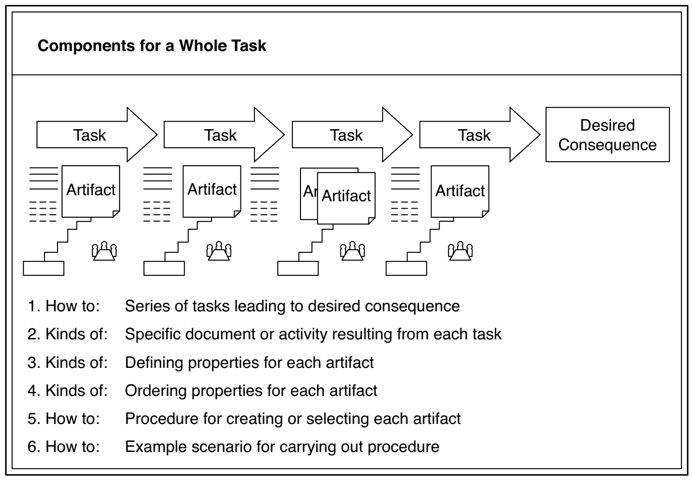

Figure 14.1 Components for a whole task. (From Merrill, M.D., *Learning Objects for Task-Centered Instruction*, 2006, http://cito.byuh.edu/merrill/Merrill_1/Merrill-1.html.)

performance of the whole task are presented as they are required by the task (task-centered approach). Key aspects of the just-in-time information presentation include partitioning, demonstration (consistent demonstration and guidance), and fading (coaching). The model stresses the identification of cognitive schemata that underlie the performance of nonrecurrent aspects of complex tasks. To promote schema induction, in addition to teaching the recurrent constituent skills presented just in time, the model also includes presentation of heuristic information to help with unfamiliar aspects of problems (structure–activation). The "basic claim of the 4C/ID-model is that its application leads to reflective expertise and, consequently, to increased transfer performance" (integration) (van Merriënboer, 1997, p. 73).

DESIGNING TASK-CENTERED INSTRUCTION

Figure 14.2 illustrates a Pebble-in-the-Pond approach to instructional development that assists designers to systematically incorporate the first principles into their instructional design (Merrill, 2002b). The steps in this approach are to: (1) specify a whole task, (2) specify a progression of whole tasks, (3) specify the component knowledge and skills required for each task, (4) specify an instructional strategy, (5) specify the user interface, and (6) produce the course.

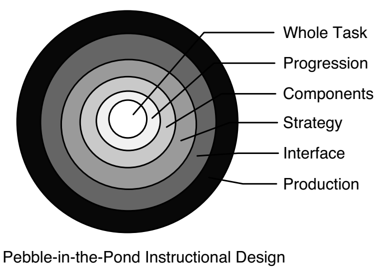

Figure 14.2 The Pebble-in-the-Pond approach to instruction. (From Merrill, M.D., *Perform. Improve.*, 41(7), 39–44, 2002. With permission.)

Merrill (2006c) elaborated the analysis required to specify the component knowledge and skill for each task in terms of portrayals of specific artifacts and information for component concepts (kinds of) and component procedures (how to) (Merrill, 1997). This component analysis (Figure 14.1) consists of the following steps: (1) find a portrayal of the artifact that is a consequence of completing the whole task (kind of); (2) identify a series of subtasks (information) leading to the desired consequence (how to); (3) for each subtask, find a portrayal of the artifact that is a consequence of completing this subtask (kind of); (4) identify the defining properties of each artifact (kind of); (5) identify the ordering properties of each artifact

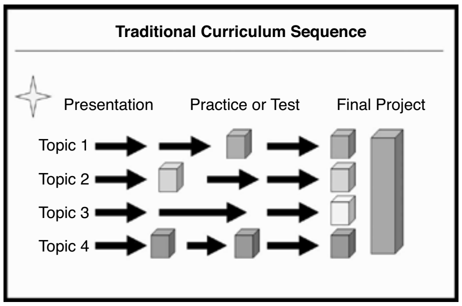

Figure 14.3 Topic-centered instructional sequencing. (From Mendenhall, A. et al., *Introduction to Entrepreneurship: How to Start Your Own Business*, 2006, http://cito.byuh.edu/entrepreneur/ main.swf.)

(kind of); (6) identify the procedure for creating or selecting the artifact (how to); and (7) identify a portrayal of a scenario illustrating this procedure (Merrill, 2006c).

Figure 14.3 illustrates a typical topic-centered instructional strategy. In this strategy, each topic is taken in turn. Information is presented and demonstrated. Periodic evaluation is administered to assess the information that is presented. Figure 14.4 illustrates a task-centered instructional strategy consistent with the first principles of instruction and the Pebble-in-the-Pond approach to instructional design. In this strategy, a whole task is demonstrated; some level of each of the relevant topics is presented and then demonstrated in the first task. A second whole task is then presented. The learner is asked to apply those topics that were presented to the new task. An expanded version of the topics relevant to the second task is presented and demonstrated for the second task. This strategy is repeated for several more tasks until all the topics have been expanded as much as required by the final tasks and the student is able to apply the topics to a new task unaided.

A new book designed to help designers use the 4C/ID model adapts the Pebble-in-the-Pond model of content-first instructional development as a recommended application of the ten steps to designing instruction for complex skills (van Merriënboer and Kirschner, 2007). Table 14.6 compares the ten development steps of van Merriënboer and Kirschner to the ripples in the Pebble-in-the-Pond model for instructional design.

CONCLUSION

Considerable agreement exists with regard to the prescriptive instructional design principles that are fundamental to effective, efficient, and engaging instruction, and the first principles of instructional design appear

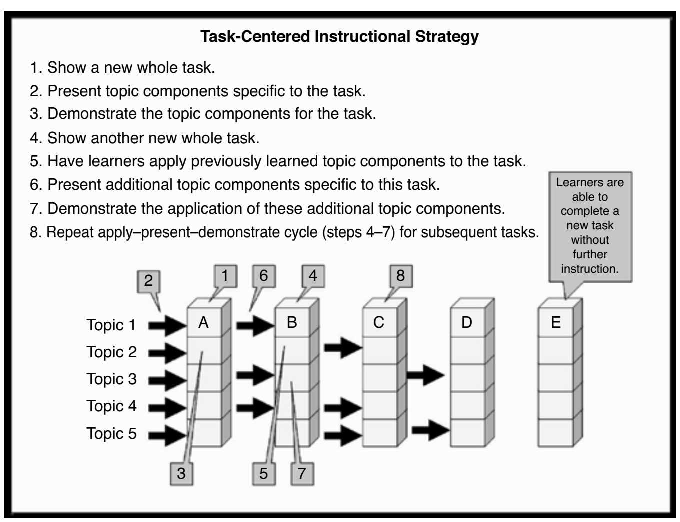

Figure 14.4 Task-centered instructional sequencing. (Adapted from Mendenhall, A. et al., *Introduction to Entrepreneurship: How to Start Your Own Business*, 2006, http://cito.byuh.edu/entrepreneur/main.swf; Merrill, M.D., *J. Res. Technol. Educ.*, in press.)

TABLE 14.6
Pebble-in-the-Pond and Ten Steps to Complex Learning

Pebble-in-the-Pond	Ten Steps to Complex Learning
Identify a whole task or problem.	Design learning tasks.
Specify a progression of whole tasks.	Sequence task classes.
Analyze the component skills for each task.	Set performance objectives.[c]
Specify an instructional strategy.[a]	Design supportive information.
Determine user interface.[b]	Analyze cognitive strategies.
Produce the course.	Analyze mental models.
	Design procedural information.
	Analyze cognitive rules.
	Analyze prerequisite information.
	Design part-task practice.

[a] van Merriënboer and Kirschner (2007) combine analysis and strategy as they discuss component skills; Pebble-in-the-Pond separates these two design functions.
[b] Ten Steps has only a minimal discussion on interface, delivery, and production; their emphasis is on the design aspects of instructional development.
[c] Pebble-in-the-Pond does not specify assessment criteria for the tasks. This is an area where the model should be improved.

Source: van Merriënboer, J.J.G. and Kirschner, P.A., *Ten Steps to Complex Learning*, Lawrence Erlbaum Associates, Mahwah, NJ, 2007. With permission.

to have a fair amount of agreement. The limited data available indicate that, when these principles are implemented in instructional products and environments, the instructional quality increases; however, far too much instruction seems to ignore these fundamental principles. It is hoped that this chapter has provided a starting point for more rigorous research to assess the validity of these principles in more situations, for more students, and for a greater variety of subject matters. In the meantime, a greater effort should be made to implement these principles in our instructional products.

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* Indicates a core reference.