Designing e³ (effective, efficient, engaging) instruction

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Abstract

Merrill identified First Principles of Instruction and then suggested a modification in the ISD ADDIE model to propose a content-first approach built around a progression of whole problems or tasks. This paper briefly describes this Pebble-in-the-Pond model for instructional development and suggests some guidelines for performing each of the steps in this model.

Introduction

Based on First Principles of Instruction (Merrill 2002a, 2007, 2009), Merrill (2002b) proposed a Pebble-in-the-Pond model for instructional development as illustrated in Figure 1. This model differs from the traditional *analyze, design, develop, implement, evaluate* (ADDIE) model in that content is specified up front, whereas in some versions of the ADDIE model the actual content to be taught is often not specified until the development phase of the *instructional systems design* (ISD) procedure. This paper elaborates the Pebble model of instructional development as an alternative approach within the general ISD framework. The Pebble model assumes some front-end analysis to identify the subject matter of the course and the audience for the instruction before the steps in this model.

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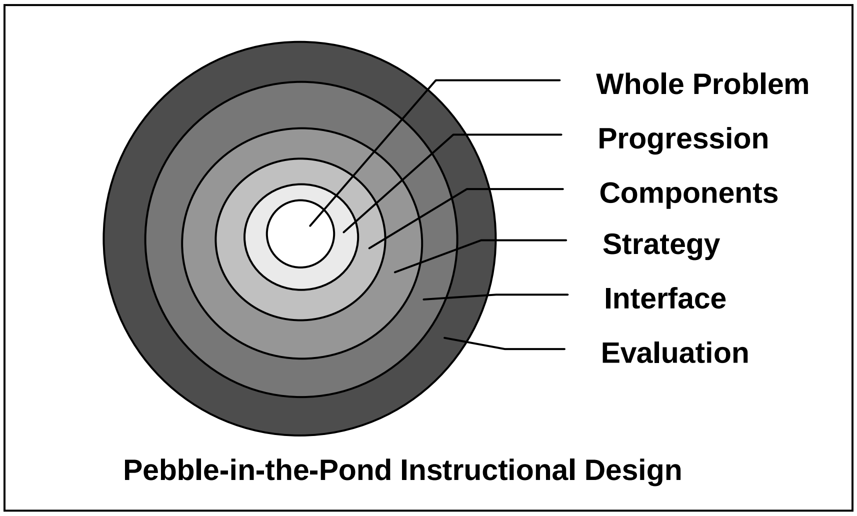

Figure 1 A Pebble-in-the-Pond Model for Instructional Development

Step 1 Specify a real-world task

What is a whole real-world problem or task?[2]

Whole problem or task – the task is one the learner can expect to encounter in the real-world following instruction. It is more than a component of a larger task. While whole tasks stand alone they may also be components of even larger whole tasks.

Specific – the problem or task is a portrayal, not a description. It is one specific instance of a class of problems or tasks for which there are multiple specific instances.

Complete – a complete problem or task includes at least three components: inputs (the givens of the task or problem); a goal (the identification of the product or activity that results from performing the problem or doing the task); and a solution (a set of activities that transforms the givens into the goal). It is also desirable to have an illustration of the problem-solving process (i.e. a representation of someone actually performing the task.)

Worked problem or task – the problem is solved or the task is complete with all the steps shown.

[2] To facilitate readability in the remainder of this paper the word *task* is often used to indicate either a *problem* or a *task*.

What makes a good task?

Ill-structured – real-world problems or tasks are not contrived. They often do not have a single correct answer.

Multiple solutions – real-world problems or tasks often can be solved in several ways and the resulting artifact or activity can take several forms.

Setting (real-world/simulation) – the best situation allows learners to do the real-world task in a real-world setting. A simulation is desirable if the real setting is dangerous, inaccessible, or potentially harmful when the task is not performed in an acceptable manner. The best simulations are those that simulate function not necessarily physical appearance.

What is the criterion for acceptable performance?

- How do you know when the learner has completed the task or solved the problem in a satisfactory way?
- How do you know when the learner has completed the task or solved the problem in a superior way?
- What are the properties to be used for ranking learner performance?

What are some activities for specifying a real-world problem or task?

- Observe and interview professionals who solve the problems or perform these tasks in their work-place.
- Study documentation about the performance of the problem or task.
- Study artifacts that result from the performance of the problem or task.
- Identify a specific goal (consequence) for the problem or task. Select an actual artifact or capture the actual activity that results from skilled performance of an instance of the problem or task.
- Select specific inputs (specific artifacts, tools, resources) that are available when one is confronted with the problem or task.
- Identify and capture the solution, the specific actions that were taken to transform the givens into the goal artifact or activity.

- Develop criterion for acceptable and superior performance.
- Check your problem or task specification against the above properties for a real-world problem or task and a good real-world problem or task.
- Capture the actions of a skilled performer as they solve the problem or do the task. Capture the problem solving process by having the performer "think-out-loud" as they solve the problem or perform the task.

Step 2 Specify a progression of whole problems or tasks

What is a progression of whole problems or tasks?

Progression – usually 3 or more tasks of increasing complexity from the same class of tasks or problems.

Whole – each task is complete, not merely a step in a larger task.

Worked examples – each problem or task should be a worked example from the task or problem class.

Same class – each problem or task, while varying from preceding problems or tasks, requires the same or similar component skills.

Specific – each task is a portrayal of the task, not merely a description, but a complete task. Each task must include specific givens (inputs), goals (desired consequence), and a solution (i.e. a set of activities that transforms the givens into the goal).

What makes a good progression?

Increasing complexity – each succeeding task includes more detail for some component skills or more component skills than the preceding task (*simplifying conditions*). No more than seven new components or revised components should be introduced for each succeeding task. The first task is the easiest version of the whole task. The last tasks are representative of the more complex tasks to be performed in the real-world.

Variability – each succeeding task, while from the same class, should be divergent from the succeeding task. That is, it should vary in those ways that tasks in the same class differ in the real world.

Component skills -- all of the component skills required by the final tasks are included in the progression.

Emphasis manipulation – for tasks that cannot be simplified an alternative approach is to emphasize only a few of the component skills for each successive whole task. This may involve doing some of the task for learners in early tasks and allowing them to apply more and more of the components as they proceed through the progression.

What are some activities for specifying a progression?

Select tasks -- gather a set of specific whole tasks. Often it is possible to gather artifacts in the work-place. For processes it is often possible to video samples of the process in the workplace.

Identify components -- Identify the component skills required for each task (See Step 3 component skill analysis).

Sequence tasks – use a *simplifying conditions* or *emphasis manipulation* approach to sequence the tasks (See Reigeluth, 1999).

Modify tasks – Adapt tasks or select alternate tasks as necessary to facilitate a smooth progression and to best enable demonstration and application of each component skill.

Step 3 Identify Component Skills for each task in the progression

What are the components of a whole problem or task?

Figure 2 shows some of the component skills in a whole problem or task and their relationship to one another.

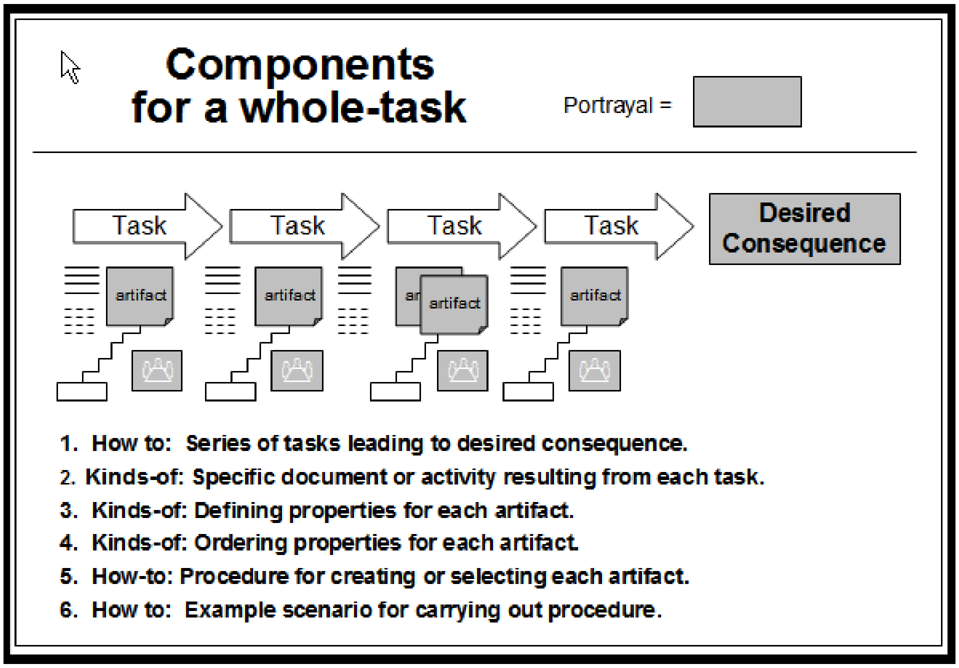

Figure 2 Component Skills for a whole task

Desired Consequence – a portrayal of the outcome resulting from solving the problem or performing the task, either a product or an activity.

Tasks – the major steps required to accomplish the desired consequence.

Artifact – a portrayal of a specific product or activity that results when a sub-task is executed.

Defining properties – a check-list for determining that the artifact is an appropriate result of performing the sub-task.

Ordering properties – a check-list for determining the quality of the artifact, for selecting one instance of the artifact as better than another instance.

Procedure – the steps required to identify or create the artifact for the subtask.

Scenario – a demonstration or portrayal of someone actually doing a specific instance of the sub-task.

The above component skills distinguish between information and portrayal. *Information* (sometimes called generalities) is general and applies to many cases. *Portrayal* (sometimes called instances or examples) is specific and applies to a specific case. Both information and portrayal knowledge components are required for effective instruction.

We have identified five kinds of knowledge that may be required for a whole task: *information-about, parts-of, kinds-of, how-to, and what-happens.* The above analysis specifies only two of these knowledge types: *kinds-of* and *how-to*. These two types of knowledge are almost always required as components of a whole task. However it is often the case that a given task will also require additional *information-about* and *parts-of* component knowledge. A demonstration of a task almost always involves *what-happens*. What-happens information is required to demonstrate and apply fault diagnosis or to enable learners to make predictions about consequences. Table 1 identifies the information and portrayal components for each type of knowledge.

Table 1 Information and portrayal components for 5 types of knowledge

	INFORMATION	PORTRAYAL
Information-about	**Facts, associations, qualifications**	**NA**
Parts-of	**Name, description**	**Location of part with regard to specific whole**
Kinds-of	**Definition – list of defining properties**	**Instances – specific examples and non-examples that illustrate properties**
How-to	**Steps and sequence**	**Portrayal of execution of a specific instance of the procedure**
What-happens	**Conditions and consequence**	**Portrayal (demonstration or simulation) of a specific instance of the process**

What are the properties of quality component skills?

Multiple artifacts – it is often the case that the single artifact or set of artifacts that pertain to the whole task under consideration may not be sufficient to enable learners to acquire the ability to identify appropriate artifacts or to select more appropriate artifacts. Selecting multiple instances of an artifact provides a richer resource for implementing an effective instructional strategy. Each instance of an artifact should of course be characterized by the defining and ordering properties.

Multiple scenarios – it is often the case that a single demonstration of performing a given procedure may be insufficient for some learners to acquire the steps for performing the procedure. Designing multiple scenarios illustrating the performance of the sub-task provides a richer resource for implementing an effective instructional strategy.

Step 4 Design an Instructional Strategy and Build a Functional Prototype

1. **Design an overall strategy for the whole course including the interface, navigation, ancillary tools, and other features**
2. **Revise your functional prototype to implement this overall strategy.**

Merrill (1997, 2009) provided guidelines and a rubric for determining e^3 (effective, efficient, engaging) instructional strategies for component skills. Merrill (2007) described an effective instructional strategy for task-centered instruction. Allen (2003) advocates building a functional prototype rather than merely developing a written design document. A functional prototype communicates the intent of the design much more clearly to subsequent producers of the instructional product and multimedia elements.

Table 2 Instructional Strategies for Component Skills

	Tell Information PRESENTATION	Ask (remember) Information RECALL	Show Portrayal DEMONSTRATION	Do (apply) info to portrayal APPLICATION
Information about	name - information	name - information	-----------------	-------------------
Parts of	name - location	name - location	-----------------	------------------
Kinds of	definition	definition	examples non-examples	classify examples
How to	steps – sequence	steps and sequence	demonstrate task	perform task
What happens	statement of conditions – consequence if… then	statement of conditions – consequence If … then	demonstrate process	predict consequences or find conditions

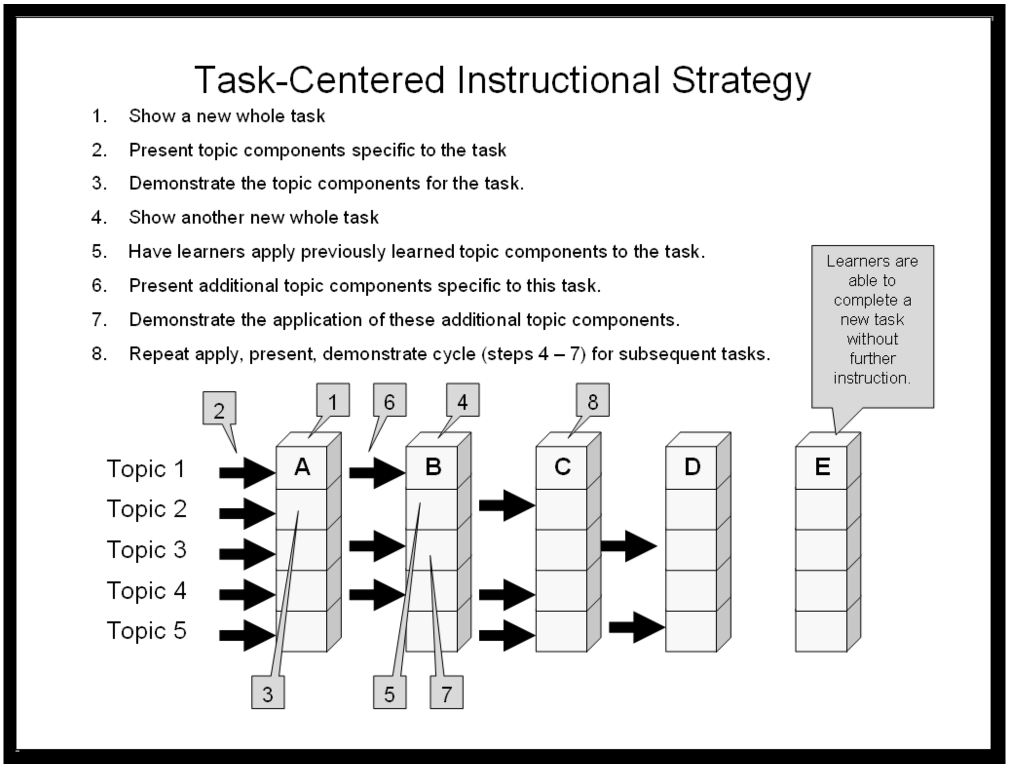

Figure 3 Task-Centered Instructional Strategy

Problem- or task-centered instruction combines problem solving with direct instruction for the required knowledge and skill (*tell*), demonstrates the problem solving process (*show*), and then engages learners in the problem solving process (*do*). In a *problem-* or *task-centered* strategy learners are engaged in doing real tasks early in the instructional sequence. Component skills (topics) are introduced as they are needed to enable learners to do each task in the progression. Notice the *tell* (2), *show* (3), *do* (5) sequence in the instructional strategy as illustrated in the figure.

In contrast with a *topic-centered* approach a problem-centered approach involves learners in applying skills to the application of whole problems early in the sequence, demonstrates the application of individual component skills in the context of a whole problem, and engages learners in a progression of problems giving them multiple opportunities to apply their new knowledge and skill.

Task 3 Design overall course strategy and interface

There are many properties that contribute to a more effective interface and navigation. These include graphics, activities to promote motivation, collaboration and learner control. The appropriate use of these properties discriminates a superior interface from an adequate interface.

What are the essential properties of an effective user interface (Allen 2003 p. 68-73)?

- Use standard conventions – don't use unique ways of interacting with the computer.
- Minimize memory burden – make interface obvious to use without having to memorize buttons, symbols, or procedures.
- Minimize errors – provide strong cues that help prevent errors.
- Minimize effort – use a single command whenever possible.
- Promote features – avoid hidden features or provide reminders of their existence.
- Contribute to the learning process – use context specific controls.
- Avoid links to essential content – Do not require the learner to link to essential content (Clark & Mayer 2003).

What are the essential properties of effective navigation (Allen 2003 p. 230-238)?

- Boundaries – let learners see the boundaries of their universe.
- Contents – use some form of course map to let learners see how the contents are organized.
- Location – let learners see where they are.
- Forward – let learners go forward
- Backward – let learners back up.
- Undo – let learners correct themselves.
- Control – allow learners to control pacing (Clark & Mayer 2003).

Task 4 Develop a final version of your functional prototype

1. **Develop required media objects**

2. **Revise your prototype to incorporate these media objects**

What are properties for the effective use of multimedia (Clark & Mayer 2003)**?**

- Graphics – use words and graphics rather than words alone.
- Contiguity – place corresponding words and graphics near each other.
- Modality – present words as audio narration rather than onscreen text.
- Redundancy – presenting words in both text and audio narration can hurt learning.
- Coherence – adding interesting material can hurt learning.
- Personalization – user conversational style and virtual coaches.

Task 5 Evaluate the prototype

1. **Design an evaluation plan for your course**

2. **Develop appropriate evaluation instruments**

3. **Revise your prototype to include student assessment instruments.**

4. **Conduct a formative evaluation of your prototype**

There are three phases of formative evaluation (Dick, Carey & Carey, 2008):

One-on-one evaluation is to identify and remove the most obvious errors in the instruction.

Small group evaluation is to (1) determine the effectiveness of changes made as a result of one-on-one evaluation and to identify any remaining problems and (2) determine if learners can use the instruction without interaction with the instructor. [For this course you should at least complete a small group evaluation of your functional prototype.]

Field test is to determine if the changes made as a result of the small group evaluation were effective and if the instruction can be used in the environment for which it was intended.

There are five types of instructional systems evaluation (Gagne, Wager, Golas & Keller, 2005). The reader should consult this source for details of these evaluation activities.

Evaluation of the instructional materials.

Quality review of the development process.

Assessment of learner reactions to the instruction.

Measurement of learner achievement of the learning objectives.

Estimation of instructional consequences.

Summary

First Principles of Instruction suggest that building the content and strategy of an instructional product around real world problems or tasks increases the effectiveness, efficiency and engagement of the learning experience. The Pebble-in-the-Pond model for instructional development is an approach that facilitates the implementation of these First Principles of Instruction. This model is a modification of the more traditional approach to instructional systems development (ISD) that moves the specification of content to the beginning of the process and then builds a strategy around solving a progression of problems or doing a progression of increasingly complex tasks. This contrasts with a more traditional topic-centered approach where each topic is taught in turn and a problem or task is left as a calumniating experience toward the end of the instructional sequence.

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This paper merely outlines some of the guidelines for developing instruction using the Pebble-in-the-Pond model of instructional development. The following references provide more detail for the interested reader. The references have been organized around the steps in the Pebble model.

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