A Pebble-in-the-Pond Model For Instructional Design

by M. David Merrill

Instructional systems development (ISD) has recently come under attack to suggestions that it may not be an appropriate methodology for developing effective instruction (Gordon & Zemke, 2000). ISD is accused of being too slow and clumsy, of claiming to be a technology when it is not, of producing bad instruction, and of being out of touch with today's training needs.

Someone said, "It is a bad craftsman that blames his tools." It should be obvious to the thoughtful observer that the problem may be the implementation of ISD, not a systematic approach itself. At the highest level of a systems approach one cannot imagine a design process that does not identify the training needs of an organization or the learning needs of the students. While learning occurs in many different environments, it is generally agreed that instruction requires that one first identify the goals of the instruction. It is equally difficult to imagine a process that does not involve planning, development, implementation, and evaluation. It is not these essential development activities that are in question but perhaps the fact that their detailed implementation in various incarnations of ISD do not represent the most efficient or effective method for designing instruction.

A more significant element is the emphasis on the process involved in developing instruction rather than the basic learning principles that this process should emphasize. Merely following a series of steps, when there is insufficient guidance as to quality, is likely to result in an inferior product. A technology involves not only the steps involved but a set of specifications for what each step is to accomplish. Perhaps many ISD implementations have had insufficient specifications for the products of the process.

For the past several years I have been engaged in an attempt to identify first principles of instruction, those principles on which different instructional design theories are in essential agreement regardless of their theoretical or philosophical orientation (Merrill, in press). John Murphy stated, "If you don't follow the instructions and people still learn, that raises the question whether there's a 'technology' there in the first place" (Gordon & Zemke, 2000). We have demonstrated that when these first principles are implemented they do promote instruction that is more effective and efficient than popular forms of existing instruction that fail to implement these principles (Boyle & Merrill, in press).

There is a set of principles or specifications that should exist in the first place and that do make a difference in the quality of the instructional product.

First Principles

What is a principle? A principle is a relationship that is always true under appropriate conditions. What is an instructional principle? An instructional principle is some characteristic of an instructional product or environment that promotes learning of some specified goal. What is a first principle of instruction? A first principle of instruction is a prescriptive design principle on which various instructional design theories and models are in essential agreement.

What are the properties of first principles of instruction? First, learning from a given program will be promoted in direct proportion to its implementation of first principles.

Second, first principles of instruction can be implemented in any delivery system or using any instructional architecture. Third, these principles are design oriented or prescriptive rather than learning oriented or descriptive. They relate to creating learning environments and products rather than describing how learners acquire knowledge and skill from these environments or products.

Many current instructional models suggest that the most effective learning products or environments are those that are problem centered and involve the student in a cycle of learning that involves four distinct phases:
- activation of prior experience
- demonstration of skills
- application of skills
- integration of these skills into real-world activities

Figure 1 provides a conceptual framework for stating and relating the first principles of instruction.
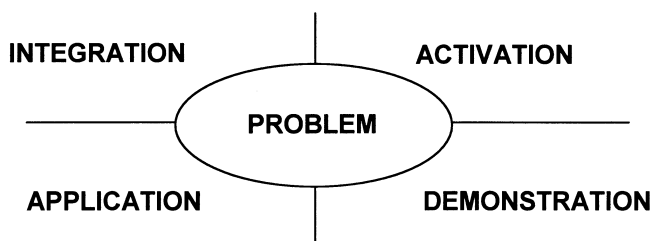

Figure 1. Phases of Effective Instruction.

Most theories stress problem-centered instruction and include some if not all of these four phases of effective instruction. These principles have been elaborated elsewhere (Merrill, in press), so the following bullets list the first principles of instruction in an abbreviated form without additional elaboration. These principles are here stated in question form, they can be converted to principles as follows: IF there is an affirmative answer to each of these questions THEN learning is incrementally promoted.

- Is the courseware presented in the context of real-world problems? Are learners shown the problem, engaged at the task as well as the operation level, and involved in a progression of problems?
- Does the courseware attempt to activate relevant prior knowledge or experience? Are learners directed to recall relevant past experience or provided relevant experience? Are they encouraged to use some organizing structure?
- Does the courseware demonstrate what is to be learned rather than merely telling information about what is to be learned? Are the demonstrations consistent with the instructional goals? Is learner guidance employed? Do media enhance learning?
- Do learners have an opportunity to apply their newly acquired knowledge or skill? Is the application consistent with the instructional goals, and does it involve a varied sequence of problems with feedback? Are learners provided with gradually diminished coaching?
- Does the courseware provide techniques that encourage learners to integrate (transfer) the new knowledge or skill into their everyday life? Do learners have an opportunity to publicly demonstrate their new knowledge, reflect on their new knowledge, and create new ways to use their new knowledge?

Pebble-in-the-Pond Development

The focus of this article is to describe an instructional design model that has been effective for implementing instruction based on these principles. This model is not a substitute for ISD but a content-centered modification of more traditional ISD that facilitates incorporating first principles into an instructional product.

Figure 2 indicates that the Pebble-in-the-Pond design model consists of a series of expanding activities initiated by first casting in a pebble, that is, a whole task or problem of the type that learners will be taught to accomplish by the instruction. Having identified an initial problem, the second ripple
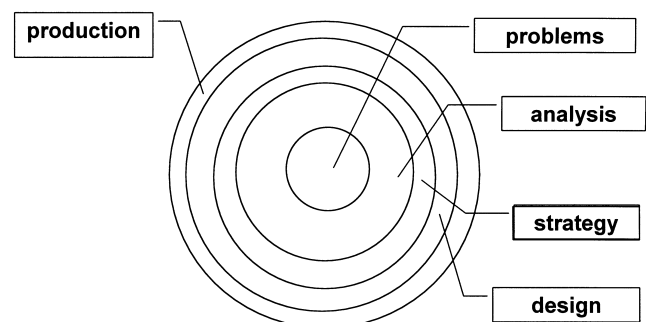

Figure 2. Pebble-in-the-Pond Instructional Development.

in the design pond is to identify a progression of such problems of increasing difficulty or complexity such that if learners are able to do all of the whole tasks thus identified, they would have mastered the knowledge and skill to be taught.

The third ripple in the design pond is to identify the component knowledge and skill required to complete each task or solve each problem in the progression. The forth ripple is to determine the instructional strategy that will be used to engage learners in the problems and help them acquire the component knowledge and skill required to complete the tasks or solve the problems. The fifth ripple is interface design. It is at this point in the design process that the content to be learned and the strategy used to engage learners is adapted to the delivery system and instructional architecture of the learning situation or product.

The ripples have now expanded sufficiently to engage in the production of the instructional materials or situation. I prefer the term *production* to the term *development* typically used in the ADDIE (analysis, design, development, implementation, evaluation) ISD model, as too often actual specification of the material to be learned is delayed in the traditional model until the development phase. In the Pebble-in-the-Pond model the content to be learned is specified first. One unique characteristic of this model is casting in the problem or whole-task pebble and specifying a progression of such whole tasks. Pebble-in-the-Pond is primarily a design model; hence we have not shown other necessary phases of the ISD process such as front-end analysis, implementation, or evaluation. These phases are still critical and necessary to a complete development process using Pebble-in-the-Pond. This model is a version of the 4C/ID model proposed by van Merriënboer (1997).

Specify a Problem

Traditional ISD advocates early specification of instructional objectives. The problem with this approach is that instructional objectives are abstract representations of the knowledge to be taught rather than the knowledge itself. Often the specification of the actual content is delayed until the development phase of ISD. Many designers have experienced the difficulty of writing meaningful objectives early in the design process. Often, after the development starts, the objectives written early in the process are abandoned or revised to more closely correspond with the content that is finally developed.

Pebble-in-the-Pond avoids this problem by starting with the actual content to be taught (the whole tasks to be completed) rather than some abstract representation of the content (objectives). Pebble-in-the-Pond assumes that the designer
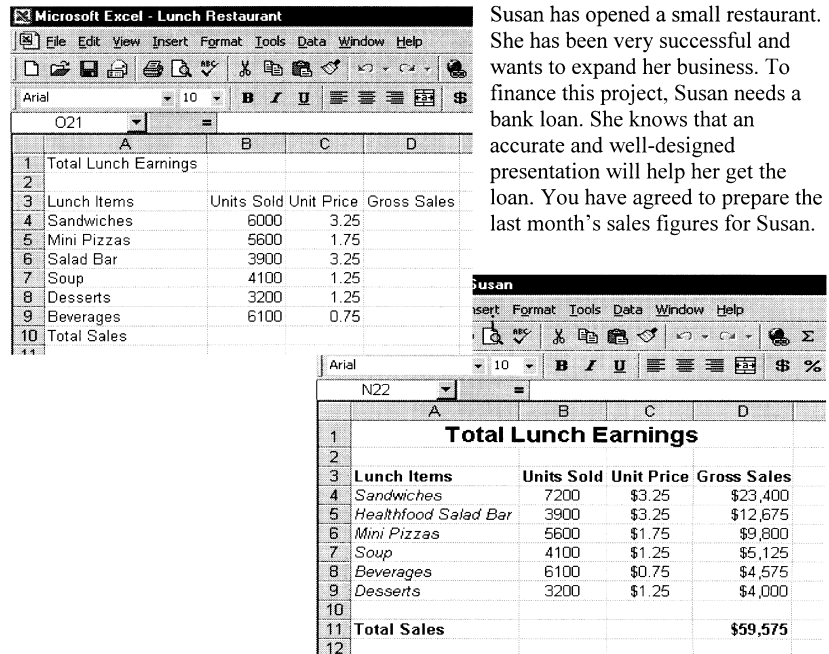
Susan has opened a small restaurant. She has been very successful and wants to expand her business. To finance this project, Susan needs a bank loan. She knows that an accurate and well-designed presentation will help her get the loan. You have agreed to prepare the last month's sales figures for Susan.

Figure 3. Specify a Problem.

has already identified an instructional goal (not detailed objectives) and a learner population. The first step, the pebble, is to specify a typical problem that represents the whole task that the student will be able to do following the instruction. The word *specify* indicates that the complete problem or task should be identified, not just some information about the problem or task. A whole task includes the information that the learner is given and the transformation of this information that will result when the problem is solved or the task completed. The third component is to work the problem, that is, to indicate in detail every step required to solve the problem or complete the task.

The example in Figure 3 shows a typical problem for a course teaching Microsoft Excel. Note that the input and output are specifically identified.

Having identified the input and the output for the problem, the third part of specifying the problem is to work the problem. Figure 4 shows the first few steps required to transform Susan's input to the final form shown. The actual analysis included all of the necessary steps.

Step 1: Create the Gross Sales formulas.

    1. Click cell D6.
    2. Type =B6*C6. Press Enter.
    3. Click D6.
    4. Copy the formula using Fill Handle from D6 to D7 through D11.

    Sample Diagnostic Procedures for Step 1:

        Problem: The learner types the formula incorrectly.
        Solution: Click cell D6.
        Type the formula again and press Enter.

Figure 4. Work the Problem.

Susan has opened a small restaurant. She has been very successful and wants to expand her business. To finance this project, Susan needs a bank loan. She knows that an accurate and well-designed presentation will help her get the loan. You have agreed to prepare the last month's sales figures for Susan.

Susan has given the Total Lunch Earnings worksheet to Isaac, one of her main suppliers, who has been successful in getting bank loans for his business. He is impressed with your work and offers three improvements. First, include a column that calculates percentage of sales. Second, add some nice borders and shading formats. Finally, set up the page to give the printout a professional appearance.

Susan expanded her business. Her restaurant is busier, and she needs more staff. To judge her new staffing requirements accurately, Susan conducted a count of customers before and after the renovations. Each survey was taken over a four-week period. You have agreed to help Susan determine her new staffing levels by calculating statistics from her second survey.

Figure 5. Problem Progression.

Progression of Problems

Having specified a typical problem for the goals of the instruction, the next ripple in the pond is to specify a progression of problems that gradually increase in complexity, difficulty, or the amount of component knowledge or skill required to complete the task. Each problem in the progression should be completely specified, including input, output, and the steps necessary to work the problem.

Solving each problem in the progression should require learners to have acquired all the intended knowledge and skill required by the instructional goals. If the problem progression does not include all the required knowledge and skill, additional problems should be added to the progression or the problems in the progression should be modified to require the necessary knowledge and skill. Figure 5 indicates the first three problems for the Excel course. For this article we have indicated only the context and situation for each problem, not the inputs, outputs, or steps required to work each problem. Actual analysis would include these data.

Component Analysis

The third ripple in the pond is to identify all the knowledge components required to complete each of the tasks in the progression. Component knowledge consists of the information, parts, kinds, how-to, and what-happens knowledge and skill required to solve each problem. Consistent with the content-first approach of Pebble-in-the-Pond, all of the information and portrayals necessary to acquire each of the necessary knowledge components should be completely specified.

For the Excel course there was an existing command-level course divided into units, lessons, and topics that taught information and how to execute each of the commands of Excel. Knowledge analysis in this situation involved associating each of these topics (commands) with a given problem in the problem progression. These topics (commands) are

mostly information-about, how-to, or parts-of types of knowledge.

Instructional Strategy

At this point in the design process all the content that will enable the learner to acquire the desired knowledge and skill should be identified and specified. Another unique aspect of the Pebble-in-the-Pond approach is that this is a complete content specification, including all the information and portrayal that will be used in the instruction.

The fourth ripple in the design pond is to determine the instructional strategy that will be used to engage the student with the content that has been specified via problem identification, problem progression, and knowledge analysis. An instructional strategy consists of combining four modes of instructional interaction with the components of knowledge to be taught: tell, ask, show, and do. The demonstration phase of instruction is to tell the learner information components and show the learner portrayal components. The application phase of instruction is to ask the learner to remember information components (the most common but usually inadequate form of practice) and to have the learner use information components to do something with the portrayal components. In addition, an instructional strategy specifies an appropriate sequence for presenting the knowledge components. Instructional strategy also specifies appropriate learner guidance and coaching during the demonstration and application phases of instruction.

Figure 6 illustrates a general instructional strategy that has been effective for problem- or whole-task–centered instruction. This instructional strategy is closely related to the instructional strategy recommended by van Merriënboer (1997).

The circles containing the letter *P* stand for a progression of problems. The triangle behind the problems represents a
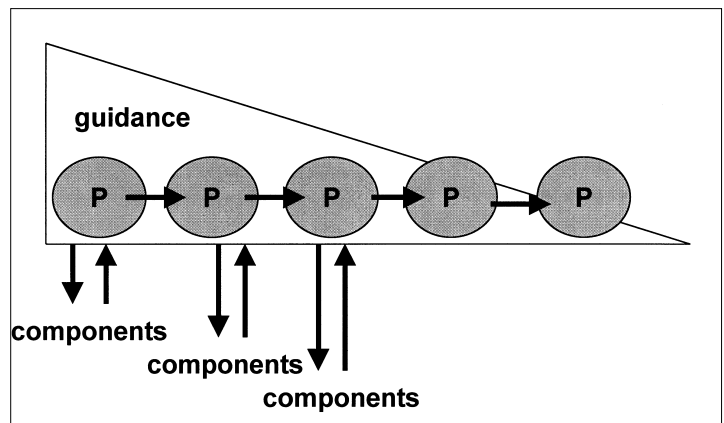

Figure 6. Instructional Strategy.

gradually diminishing amount of learner guidance or coaching required. The components are the information and portrayal of each of the types of knowledge required for each of the problems.

The strategy is executed as follows: The first problem in the sequence is shown to the learners, and they are informed that they will learn to solve such a problem or complete such a whole task. The down arrow indicates that the learners are then taught the knowledge components necessary to solve this problem. The learners then return to the first problem and the instruction shows them how to work it. Learners are next shown the second problem in the sequence. In this case learners are required to work as much of the problem as they are able based on the information and portrayal they have acquired from the component instruction and the first worked problem. Then the additional knowledge components required for the second problem are taught to the learners. The learners then return to the second problem and the instruction demonstrates the application of the new knowledge components in the context of the problem.

There may be several worked problems in the first part of the sequence, depending on the complexity of the problems. In the Excel example, there were two worked problems at the beginning of the problem progression. In each succeeding problem in the progression, learners are required to complete as much of the task as possible using the knowledge components they have already acquired and are then taught new components and shown how these new components are applied to the problem. Eventually all the knowledge components required for the problems in the progression will have been acquired and the learners are required to apply their newly acquired knowledge and skill to solve additional problems or complete additional whole tasks. The later problems in the sequence are the assessment of the newly acquired knowledge. If the learners can successfully complete the later tasks in the sequence then they have successfully acquired the desired knowledge and skill.

The Excel Course strategy presents Susan's data and the final worksheet that will result after the task is completed. It then lists the topics from the existing command-level course that are necessary to complete the problem and encourages learners to study these topics. The existing course teaches each command using a Simon-Says, action-by-action demonstration where learners are directed to execute each command. The strategy then returns learners to the first problem and shows how each of the commands is applied to this problem. In this case the strategy sequences the commands as they are required to complete the task. The strategy repeats this same approach for Problem 2 in the problem progression. The strategy then presents Problem 3 and encourages learners to study the new topics that apply to this problem. The strategy then prompts learners to complete the prompted task as follows: "In the previous scenar-

ios, you were guided step by step in the application of the commands to complete the scenario. In this scenario, you will not be given this step-by-step guidance. You should first review the modules teaching the commands that you will need to complete this scenario. Then you should try to complete each task in the scenarios on your own. If you need help, there is learner guidance provided at the end of the exercise for each of the tasks. You will learn more if you try to do the task before you look at this guidance material and use this guidance only when you are unable to perform the required commands. After each task, you will be shown an interim spreadsheet that you can use to compare with your own work. In this scenario, you will design a new worksheet." The strategy repeats this procedure for Problems 3 and 4.

Pebble-in-the-Pond is a viable alternative to traditional ISD and overcomes some of the major objections raised.

For Problem 5 the strategy uses an on-your-own approach, as follows: "In this exercise, there is no Learner Guidance section. If your screens do not match the sample screens provided, you should return to the Excel course and review the appropriate modules." The strategy has previously demonstrated (via Problems 1–4) and provided learners a chance to apply all the information and commands required by this problem. The strategy encourages learners to solve the problem and to return to the presentations of the individual commands if they have trouble.

Finally, the strategy presents learners with three more authentic tasks. The first of these is as follows: "In this authentic task, you apply your knowledge of Microsoft Excel 2000 to redesigning a worksheet. Jake has returned from a holiday in France. He had set a budget for the vacation and wants to compare his actual and planned expenses. He is unsure of the correct exchange rate. You have agreed to work this out for Jake in return for a bottle of vintage French chardonnay. Jake has given you the basic information on the following worksheet named Holiday. [In the course a worksheet appears here.] You must create formulas and redesign the worksheet to make it look like the following example. [In the course a worksheet appears here.] These authentic tasks are the assessment for the course. The strategy directs learners to work these problems

on their own. Learners are not allowed to reference help files or return to the previous instruction during the authentic tasks.

Does Pebble-in-the-Pond Work?

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 the author, developed scenarios for a course in Excel. The illustrations in this article represent these scenarios. They then developed a problem-progression-component-instruction with guidance strategy for teaching this course as described in this article.

The investigators selected study participants from among NETg customers who volunteered to participate in the study. There were three groups:
- Group 1, the scenario group (n=49), received instruction as described in this article.
- 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 the commands and operations of Excel using a guided demonstration that instructs learners to execute a command or series of commands and then see 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.
- A control group (n=30) received the final three authentic scenarios without any prior instruction in Excel. The instruction was delivered on line 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 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.

Conclusion

This article describes some first principles of instruction derived from existing instructional design theories and models that form the specifications for effective and efficient instruction. It also describes a Pebble-in-the-Pond modification of the ISD process that facilitates the development of instruction that meets the specifications for these principles. The study also demonstrates that instruction that implements some of these first principles and is developed using the Pebble-in-the-Pond model is more effective and efficient than instruction that fails to implement these principles. Pebble-in-the-Pond is a viable alternative to traditional ISD and overcomes some of the major objections raised by Gordon and Zemke (2000). By developing the content first, Pebble-in-the-Pond is a more efficient development process. Pebble-in-the-Pond implements first principles of instruction that have been demonstrated to make learning more effective and efficient. This approach results in instruction that works and it is consistent with the current view of requiring authentic experience in real-world problems. 🏔

References

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M. David Merrill is a professor of instructional technology. Since receiving his PhD in 1964, his primary interest has been and still is investigating what makes for effective, efficient, and appealing instruction. In the pursuit of this goal, David has made several major contributions to the field of instructional technology. In the 1970s, he was a primary designer of the authoring system for TICCIT, an early CBT system. In the 1980s, he developed Component Display Theory and Elaboration Theory that are still widely used as guides for effective instructional development. In the 1990s, David's work included knowledge objects and instructional transaction theory primarily aimed at facilitating the automation of instructional design. His recent work is an attempt to identify those first principles of instruction that are common to most theories and models of instruction. David was recently awarded the 2001 Distinguished Service Award by AECT "for advancing the field of Instructional Technology through scholarship, teaching, and leadership." He may be reached at merrill@cc.usu.edu.