Practice Resources

5

Learning Outcomes:

- Describe what is a practice resource;
- Design more effective drill & practice resources; and
- Design a digital resource for procedural knowledge development.

5.1 What Is a Practice Resource?

In addition to declarative and conceptual knowledge, curriculum content for most subjects includes procedural knowledge, such as, knowledge of problem solving procedures, algorithms, configuration of lab equipment, and other conceptual and practical tasks requiring skills. Procedural knowledge is best described as curriculum knowledge content of "tasks specific rules, skills, actions, and sequences of actions employed to reach goals" (see Cauley 1986).

Practice resources primarily aim at assisting the development of this form of knowledge for learners. Such resources do not simply present declarative information about a procedure we expect learners to remember. Rather, if effectively designed, these resources allow learners to learn with and through interaction and engagement with the content of the display. Contemporary representational technology tools, with their visual and interactive affordances, allow for the design, development and delivery of resources that can effectively be used in this context. For this to be achieved, we need to move beyond simple forms of practice items most widely used—drill & practice forms, such as, short-answer and multiple choice questions with simple wrong or right responses, when ineffective or no feedback is

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provided at all—and adopt a design approach where representations and interactivity are used to provide a tool for the development of procedural knowledge.

Important
Contemporary representational technology tools, with their visual and interactive affordances, allow for design, development and delivery of resources that can effectively be used in the context of development of procedural knowledge.

However, most often practice resources are designed and used as a means for drill & practice, and quizzes that check students' recollection of certain factual and declarative knowledge that they are expected to remember for reproduction at exams. Practice resources are most often embedded within presentation resources, and used as a means of reinforcing chunks of information that learners learn.

In the approach proposed in this book, practice resources are separated from other forms of digital resources for learning, with the purpose to allow optimal reusability within a variety of resources other than presentations. Furthermore, this separation allows designers to focus more on the development of resources to target procedural knowledge content specified by a curriculum, rather than to continue focusing on the design of resources for transfer of facts and declarative information, and subsequent checking if that knowledge has been remembered.

In this chapter, we will examine some of the possibilities for more effective design of practice resources. At the same time, we will look at some fundamental instructional principles for designing interactive drill & practice, so that such resources can be made more educationally effective. We will discuss practice items in two forms: drill & practice (including quizzes), and procedure practice, and acknowledge the possibility for games to be considered under this category of digital resources for learning.

Activity 5.1
How would you design a practice item for the learning of a procedure of measuring patient's blood pressure? Sketch your idea, or try prototyping something with a tool of your choice.

5.2 Drill & Practice Resources

The drill & practice form of practice resources has been most widely used in education in presentation resources, such as, in instructional multimedia packages and computer based instruction, or within on-line learning management systems.

Numerous technology tools such as Hot Potatoes, tools within an e-learning system, such as, Moodle or Blackboard, and even Web 2.0 platforms such as those empowered by Google Forms, allow for the easy creation and delivery of drill & practice questions. Teachers around the world have been using these tools to leverage upon their affordances, and develop drill & practice questions for implementation in their teaching. This looks promising to teachers, as it gives them a sense of creating interactive resources for their own use with ease. Teachers appear empowered to quickly create a set of drill & practice questions by copying text from somewhere else (e.g., a Word document), and pasting into their resources for configuration. Resources can be easily implemented and teachers can collect responses from students automatically, thus, removing the required time and effort to manually check through students' work. Often, these are used as a tool for assessment.

However, there are limitations and further room for considerable improvements in such practice. Although teachers are easily embracing these tools, often it appears, based on the author's review of numerous drill & practice questions that sound instructional design principles are absent most often. Furthermore, it appears that rarely, visual and interactive affordances of contemporary representational technology were utilized within question or corresponding feedback.

We will use a simple example to illustrate this limitation, and propose some design principles. Let's say a drill & practice question is created to ask a learner the question presented in Fig. 5.1.

Teachers, using one of the technology tools mentioned previously, can easily create such a question. However, what happens most often is that, once student selects a response A, B, C or D by pressing a corresponding key on a keyboard (or clicking on the selected answer by a mouse, or a finger via a mobile device), they are told if they are correct or incorrect. Often, feedback is limited to simple text, such as, 'Right!', 'Well done!', 'You are correct', 'Wrong', 'Incorrect', etc. In some

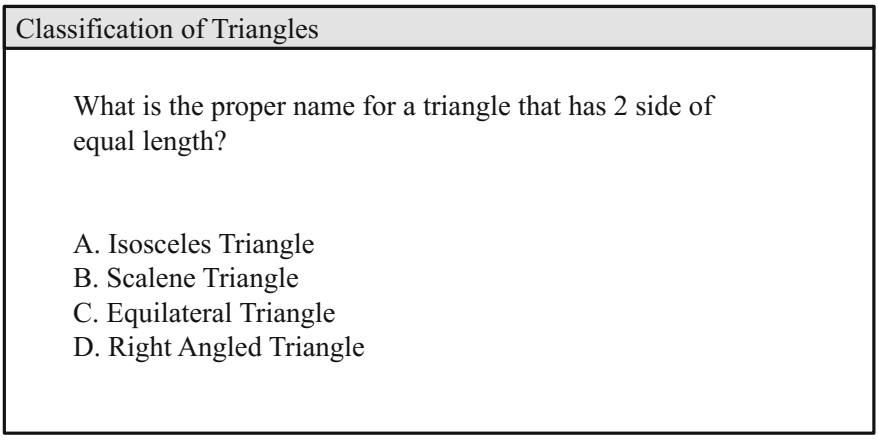

Fig. 5.1 An example of a simple practice resource

instances, students receive, for example, a green tick (✓) acknowledging correctness, or an alternative red sign (✖), acknowledging incorrectness. These are usually automatically provided by the system supporting the development of such a resource. Furthermore, the system might also provide auditory feedback in the forms of a pleasing sound when a correct response is selected, or a disturbing sound if an incorrect response is selected. Rarely, students are given the opportunity to try again and correct their mistakes; neither authoring tools in available platforms support this to be integrated in design of a practice resource.

So, what should be done in terms of design to make this more effective as a practice resource? The first option is to do with the presentation of the question. Visual representation can be used to more effectively present this question in a way that will support learning. For example, this can promote learning of mathematical representations, as well as the linking of mathematics to language by corresponding the visual to textual information. So, the question might appear, as presented in Fig. 5.2.

There are some additional elements included in this screen. These include additional instructions on how to answer the questions, as well as some formatting of the text to highlight important and related information. Furthermore, and probably most importantly, attention should be given to the role of feedback in such resources. Telling learners that they are 'wrong' or 'correct' does not carry any significant educational value. Feedback must be constructive, and serve as a tool for learning. These are some guiding principles in respect to feedback:

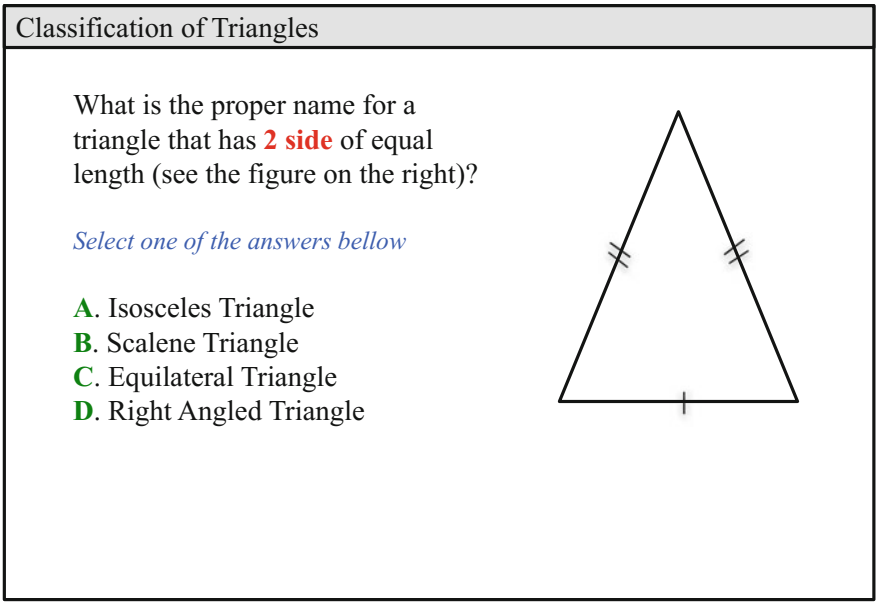

Fig. 5.2 More effective display of a practice resources (visual representation is used to enhance presentation and support learning)

- When a learner answers a question *correctly*, this should be used as an opportunity to provide further information, and extend his or her knowledge beyond the sole content of the question. So, the feedback might be: "*Correct! A scalene triangle can also be a right-angled triangle*". Instructions on what to do next will then be provided, e.g., '*Click go to the next question*'.
- When a learner answers the question *incorrectly*, this should be used as an opportunity to point to his or her mistake(s), provide some information that can help the learner to improve (remediation), and provide another opportunity to answer the question. So, for example, if a learner selected "*C. Equilateral triangle*" as an answer, the feedback might be: "*Incorrect! Equilateral triangles have 3 sides of equal length. You are looking for a triangle that has only two sides of equal length. Please try again*". The feedback might even contain a graphical representation of an equilateral triangle. In this way, a learner can focus on the mistake made, and will attempt to correct this mistake by considering new information provided.
- When a learner is *partially correct*, that is, in the example if he or she selects "*D. Right-angled triangle*" as an answer, this should be acknowledged and further information provided with an opportunity to provide an answer in the next attempt.

Important
A practice resource must include appropriate feedback provided to learners based on their responses. Providing feedback is a critical aspect of the design of practice resources. Learners should be given an opportunity to reflect on their responses.

In addition to limitations associated with the feedback, not providing learners an opportunity to correct their mistakes is another serious limitation of many of the drill & practice questions reviewed by the author. Learners should be given an opportunity to correct their incorrect answer by thinking more about the question asked and responses they provided. It would not make much sense to provide more than one additional attempt, as a learner might easily guess the correct answer by eliminating previous unsuccessful attempts. If a learner was not successful in the second attempt, then, remediation can be provided (some other resources may be used to learn relevant content).

5.3 Procedure and Practice Resources

However, until this stage, it can be reasonably assumed that this kind of drill & practice does not fully address procedural knowledge. It appears that these are more about practicing recall of declarative knowledge. What can be done to build

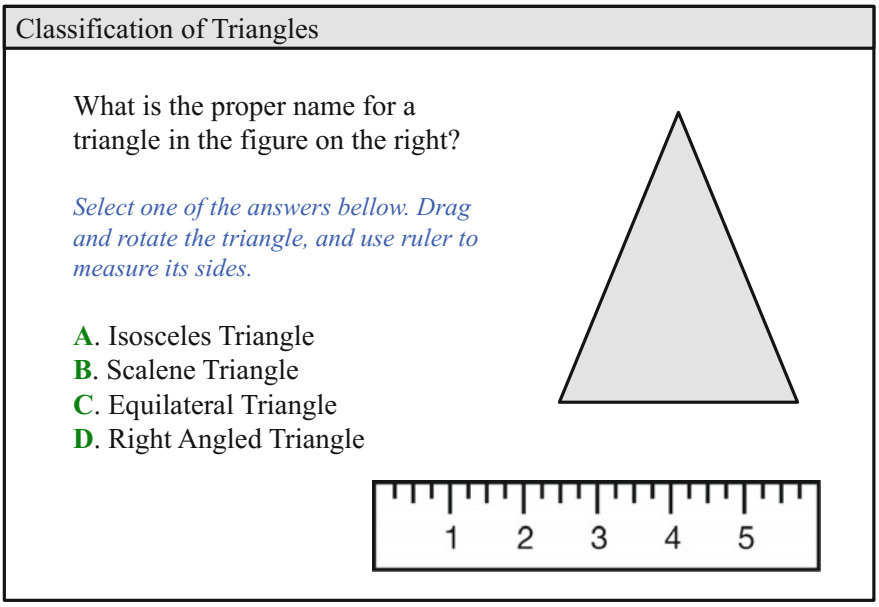

Fig. 5.3 An example that integrates aspects of procedural knowledge

procedure in the process of answering questions? This is illustrated in the redesigned example featured in Fig. 5.3.

Rather than telling a learner that the triangle under question has two sides of equal length, he or she could be instructed to use a ruler and measure the lengths of the sides, and based on these, determine the answer. Such questions can become even more sophisticated by providing an option to select a tool for this task, for example, a protractor instead of a ruler, just a protractor, or both of these tools.

There are a number of ways how this question can be designed and answered by a learner. One option presented so far, is multiple choice where a learner can press a key on a keyboard, or click on a selected answer. An alternative can be that a learner checks a box next to the selected answer, or drag and drop a selected answer in an answer box. However, these interaction possibilities do not, in essence, change the effectiveness of this resource for learning and, moreover, these might overload cognitive processing. Also, an option is to have a text input box for a learner to type in his or her answer. We must note that in the case of open-ended answers, a learner might be penalized and told he/she is wrong because of a spelling mistake, rather that of knowledge of content (e.g., if they misspell isosceles). Also, in these cases, a learner might produce an anticipated partially correct answer (e.g., isosceles angled triangle), or incorrect answer (e.g., equilateral), or a totally unanticipated answer (e.g., Bermuda triangle). For each specific question, a designer must determine the most appropriate form of interaction that can be used to answer a question, so that the most appropriate feedback can be applied to support learning.

Important
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A single design of a resource can be articulated in a form that affords multiple practices, and even prevents the copying of answers between learners. Figure 5.4 illustrates such a design.

Affordances of contemporary representational technologies allow that an image of a triangle is randomized, that is, selected from several images available to the resource, or drawn dynamically by a program. It can be presented as different forms of a triangle with different sizes of sides and angles. At the same time, the scale on the ruler can be randomized, so that each time a learner activates the question, a different combination is presented, requiring different answers. Internal logic of the resource will calculate the required answer and will compare that value to the value given by a learner. Again, feedback will play a critical role in enabling a learner to learn from this experience, and extend his or her knowledge even when the correct answer is provided.

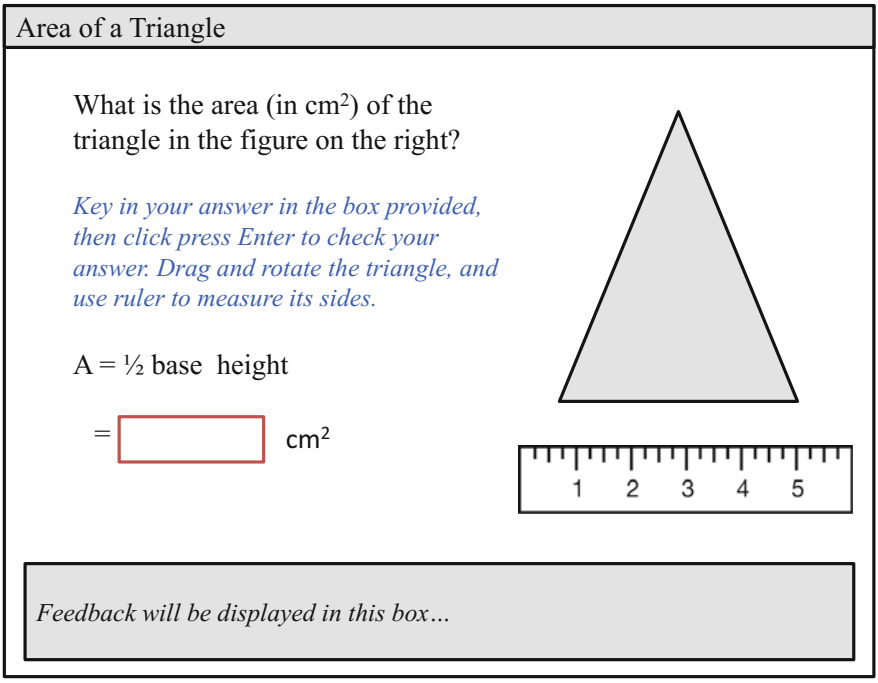

Fig. 5.4 A practice resource that allows multiple practices by utilizing a random display of parameters

A key problem is that designing such items is beyond the competencies of average teachers and instructional designers, as well as beyond the features that standard learning management tools provide and, therefore, require more extensive involvement of a technical specialist to implement such ideas. Nevertheless, instructional designers, as well as teachers, have always been professional who bridge between curriculum requirements and actual implementation, and they need to be fully aware of these possibilities when designing and deciding on forms of resource to use in their practice. Help should be sought from technical specialists who can implement their ideas by developing these resources in a form ready for implementation (e.g., multimedia developers or programmers).

Activity 5.2
Consider this question:

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When exposed to lower air pressure, the boiling point of water:
A: Increases
B: Decreases
C: Does not change
==========
Examine this question carefully, and attend to the following:

- *How would you design a practice item to engage learners to use certain procedures, such as using measuring instruments (e.g., temperature gauge) to answer this question?*
- *What feedback you should provide for an incorrect response? What about feedback for a correct answer?*
- *How to reframe this question to make it more real-life and authentic (e.g., "It takes much longer to boil eggs in the hills than in the plains, because?")?*
- *How can this question be randomized in other to prevent learners from copying answers from each other?*

For learning, practice items can be designed to fully address the requirement of a procedural knowledge in numerous cases, or at least to bring learners' understanding and skills close to those that they would require in working with real tools. Ultimately, in many cases, learners would be required to move to use and work with real tools to complete their learning of procedures.

Figure 5.5 shows an example of such resources. This example was designed while the author was working at a technical education institute with teachers from the Mechanical Maintenance department. These teachers held the belief that technology resources are good for the learning of declarative knowledge, but these cannot really help them to teach the procedures required in the maintenance of

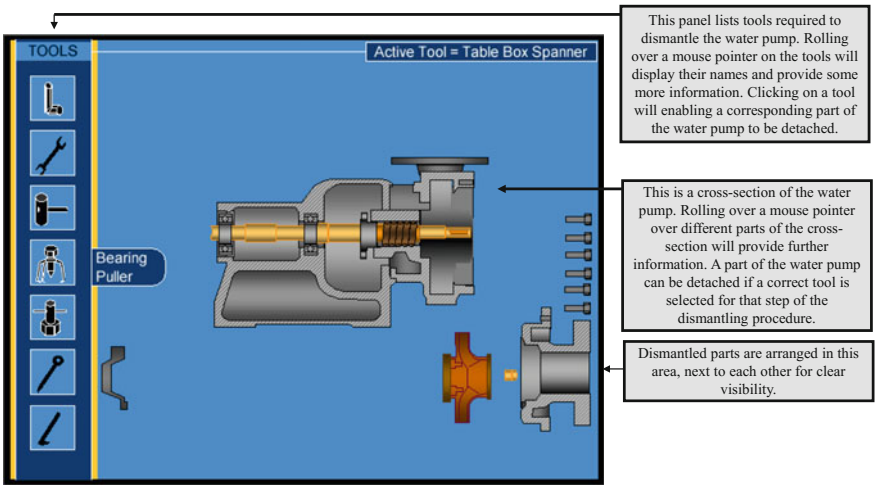

Fig. 5.5 'Water Pump Maintenance' Practice resource

various equipment. Presented with this challenge, the author was determined to prove the contrary, and through this process, the practice resource presented in Fig. 5.5 was developed.

This practice resource shows a cross section of a water pump. The task for a learner is to dismantle the pump, and assemble it back in a particular order of steps. Parts of the pump must be removed in a specific order, or put back together in the reverse order. Each part of the pump can only be removed if a specific tool is selected for use. So, a learner is conditioned to select a specific tool (e.g., bearing puller), in order to remove a specific part (e.g., bearings). Various interactive elements drive learners to approach the procedure in the correct order by using correct tools. For example, from the beginning, a learner is not able to move any part of the pump by dragging it away from the cross section. A pop-up message instructs a learner that he or she should select the appropriate tools to approach the first step of the procedure. Then, once a learner has selected a spanner he or she will be able to remove the first part (casing cover). Rolling a mouse pointer over the cross section of the pump will display pop-ups with names and short descriptions of the different parts. The same will apply when a learner moves the mouse pointer over different tools on the left of the display.

Finally, the learners visit a workshop, and work on a real pump using real tools. However, by this time, they will have a well-established understanding of what is involved in dismantling and assembling a water pump, and able to visualize mentally how the pump looks inside, how parts are distributed and what tools are required. This dramatically reduces the amount of time required to learn to perform the final real-life procedure, while making learning possible at anytime and anywhere beyond the workshop (not to mention possibilities of minimizing accidents, damage to real equipment and limitations in terms of the number of real pumps available for students to practice).

When this practice resource was used in a classroom with learners, it was observed that they were exceptionally enthusiastic and engaged. Some learners even set up a competition between themselves to compete who will dismantle and assemble the water pump faster. This gave a special dimension of a 'game' to this particular practice digital learning resource.

Nevertheless, this particular practice resource is obviously different from the previously discussed case of drill & practice format. Because such a resource contains a certain degree of realism, that is, they reassemble, or simulate real world, in this book, we argue that such resources are a special form of *practice simulation* (e.g., Rutherford-Hemming and Lioce 2016; Sunnqvist et al. 2016). Other forms of practice resource might include those that incorporate aspects of *digital games* (e.g., Beserra et al. 2016; Hainey et al. 2016; Reinders 2012). When we think of a game in teaching and learning, there are a number of possibilities. This means that the idea of games cannot be limited only to a specific form of digital resources for learning. Most relevant to this chapter is that there are digital resources for learning incorporating representations and interactivity to drive a learner to practice certain procedures in game-like fashion. In this sense, a game is a form of a representation resource. The design of such resources most often places a learner in a situation to pursue a certain goal, such as high scores, moving to the next level of complexity, or competing against the machine or others. Essentially, what learners are doing is not about learning new conceptual knowledge (although some conceptualizations might occur incidentally), rather, they repetitively practice certain procedures until some level of mastery is achieved. Games can be considered as a special form of learning activity as well. In this case, the game is not a digital resource, but a strategic approach to achieving learning outcomes. Furthermore, a game might be a complex, digital and social environment, where multiple networked players engage in interactivity, collaboration, competition, and achieving specific goals. In the case of a digital game as a special form of presentation resource, it is a digital resource designed to mediate a learning activity—not an activity in itself—rather than just a resource used in a learning process.

Activity 5.3
Design a practice resource to help a learner to practice a procedure of using a protector to measure angle sizes.

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