

Does Practice Makes Perfect?

This is a chapter from a white paper curated by Anne Guetschow entitled "[Tactics to Improve Student Learning](#)."

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Does Practice Make Perfect?

“Can you recall the hours you spent in math courses working practice problems both in class and afterward as homework assignments? Practice exercises matched to the learning outcomes are one hallmark of effective courseware.... Effective practice exercises that require learners to process content deeply also impose considerable load on working memory. For novice learners who need to devote working memory capacity to building new schemas, working many practice problems slows learning by overloading working memory. The good news is that recent research offers proven techniques to achieve the same learning in less time by starting with worked examples that transition gradually into practice exercises.”

Guideline 17: Replace Some Practice Problems with Worked Examples.

What is a Worked Example?

“A worked example is a step-by-step demonstration of how to perform a task or solve a problem. You may present worked examples in diverse formats and modalities including text in books or in narrated animation. Examples are nothing new, since good instruction has always used them. However, what is new is the proven effectiveness of examples to replace practice and get equivalent learning results in less time and with less learner effort!”

Acceleration of Expertise in the Classroom.

“While the replacement of some practice problems with worked examples looked promising, it was important to see whether these findings applied to actual classrooms....How would worked examples fare in an actual classroom with longer lessons and different topics? Zhu and Simon (1987) report one field trial conducted in Chinese middle schools in which a traditional three-year course consisting of two years of algebra and one year of geometry were successfully completed in two years by replacing some practice problems with worked examples! Here we see real-world evidence of acceleration of expertise through a cognitive load reduction technique. In summary, the laboratory research showed that learning time could be saved under controlled conditions by substituting some practice problems with worked examples, and the field trials showed that this technique could be adapted to actual classrooms.”

The Psychology of Replacing Practice Problems with Worked Examples.

“It comes as no surprise that actively solving practice problems imposes much more mental work than reviewing worked examples that illustrate how to solve those problems. When studying worked examples, limited working memory capacity can be devoted to building a schema of how to perform the task, giving a worked example to a student just prior to solving a similar problem provides the learner with an analogy available while solving the problem. When having to actively solve

a problem without the benefit of an analogous example, most working memory capacity is used up in figuring out the best solution approach, with little remaining for building a schema.”

Guideline 18: Use Completion Examples to Promote Learning Processing.

“Although the use of worked examples to replace some practice proved effective in a number of experiments, there is a potential drawback to worked examples. To be effective, a worked example must be studied. An example ignored will not promote learning. Some learners may be tempted to either skip the worked examples completely or to give them a cursory review and thus miss the benefits they offer. In contrast, practice problems demand deep processing for solution. In fact, many practice assignments ask learners to show their work as evidence of this deep processing. Deeper processing leads to better learning. One way to minimize learners ignoring worked examples is to replace worked examples with completion examples.”

What are Completion Examples?

“A completion example is a hybrid between a practice assignment and a worked example. In a completion example, some of the steps are demonstrated as in a worked example, and the other steps are completed by the learner as in a practice problem....In order to complete the problem, the learner will have to actively process the worked out portion and then overtly respond to the open portion.”

The Psychology of Completion Examples.

“Like worked examples, completion examples reduce cognitive load because schemas can be acquired by studying the worked-out portions. Requiring the learner to finish the worked example ensures that she will process the example deeply. Research has shown that learners who process examples more deeply learn more.... In summary, a completion example offers psychological balance. It reduces cognitive load by incorporating some worked-out elements and it fosters deep processing by requiring completion of the remaining elements.

Guideline 19: Transition from Worked Examples to Problem Assignments with Backwards Fading.

“So far we have seen that you can increase efficiency of your lessons by replacing some practice with either worked examples or completion examples. This technique manages cognitive load of novice learners by freeing up working memory capacity to build new schemas by study the examples. However, as learners gain expertise during their training, eventually worked examples actually become detrimental and learners are better off with lessons in which they work all the problems. This is because once a learner has acquired a basic schema for the

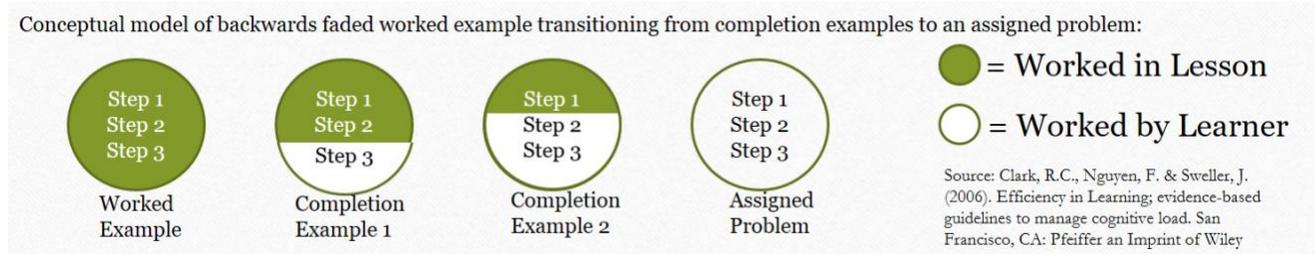
skill or concept, she learns best by applying the schema to problems rather than investing redundant effort in studying more worked examples.

The best way to accommodate learners as they build expertise is through a process called *backwards fading* of worked examples. In lessons that apply backwards fading, worked examples transition gradually into practice problems coincident with a gain in learner proficiency. Fading techniques allow you to accommodate a gradual learning process.

Initially learners should devote as much working memory capacity as possible to building a schema that will underpin the new skills. As they gain expertise, understanding is promoted as they do more and more work. In advanced stages of learning, learners need to build high competency levels by solving many practice problems themselves.”

What is Backwards Fading?

“Fading is a process in which completion examples evolve into full problem assignments by a gradual increase in the number of steps that must be completed by the learner. The lesson begins with a full worked example that provides a model for the learner. The next few worked examples are completion examples in which more and more of the work is done by the learners. By the end of the lesson, full problems are assigned...As you can see, a sequence of examples (circles) requires greater and greater learner input (white portion of circle) to complete. In this way, instructional support is faded gradually as the learner gains expertise.



Lesson start -----Lesson end

The Psychology of Fading.

“...novice learners who are most susceptible to cognitive overload will benefit the most from worked examples. As learners gain expertise, worked examples can actually depress learning because it requires more mental effort for an experienced learner to study a worked example than to simply work a problem herself. This is because a learner who has built a schema for working problems can best solidify his or her schema by exercising it. Having to study a worked example, once the schema has been established becomes a redundant mental activity and learning is disrupted.”

Applying the Research.

“Taken together, the experiments on worked examples recommend that you:

- Begin your lessons with worked examples followed by a similar problem.
- Follow the first worked example with a series of completion examples in which the first steps are worked out and the final steps are left for the learner to complete.
- End the lesson with full practice assignments.

This transition from worked example to practice by way of backwards faded completion examples provides learners with a smooth trajectory from novice to expert.”

NOTE: Guidelines 25 – 29 discuss other adjustments you need to make as learners gain expertise.

Guideline 20: Display Worked Examples and Completion Problems in Ways that Minimize Extraneous Cognitive Load.

“We have seen that worked example-problem pairs and completion examples are more efficient vehicles for learning than assigning all practice problems. However, a poorly formatted worked example can add extraneous cognitive and thus negate its potential benefits. To be effective, worked examples should be formatted in ways that minimize cognitive load. In Guidelines 4 – 7, we discussed the use of audio (modality effect) and use of integrated text formats that minimize split attention. The modality effect also applies to multimedia or classroom instruction and recommends that you describe on-screen visuals with words presented in audio narration rather than with text.

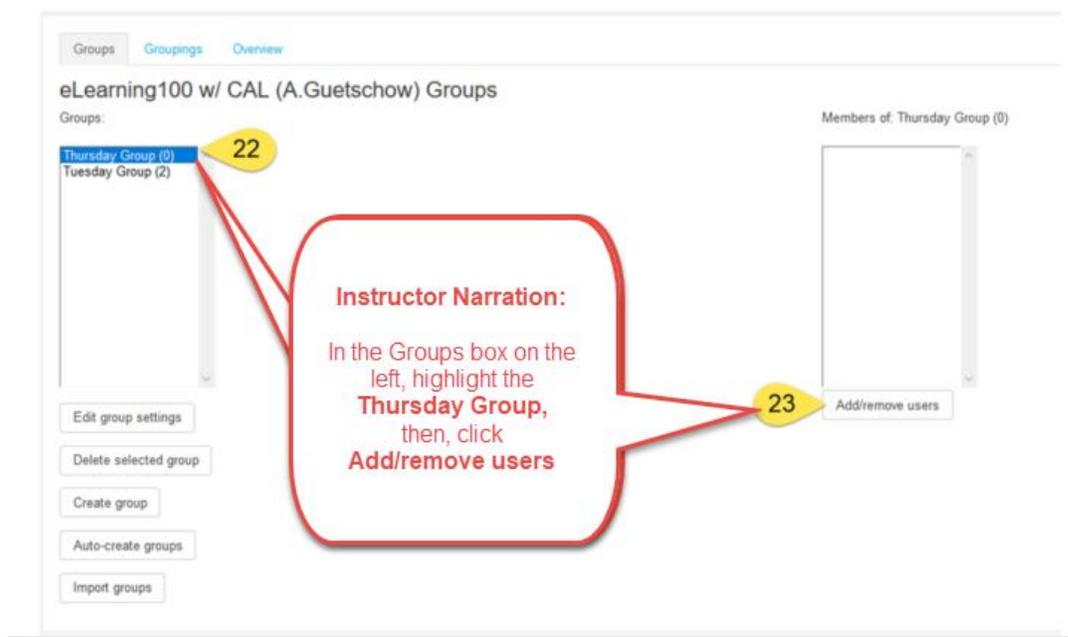
Presenting content in complimentary visual and auditory modes distributes the load between the visual and auditory storage centers of working memory. The use of integrated text applies to either multimedia or paper-based materials and recommends that text that describes visuals be physically integrated nearby the visual. This reduces visual search by doing the integration work for the learner. These principles apply to worked examples that use visual illustrations.”

Applying the Modality and Split Attention Principles to Worked Examples.

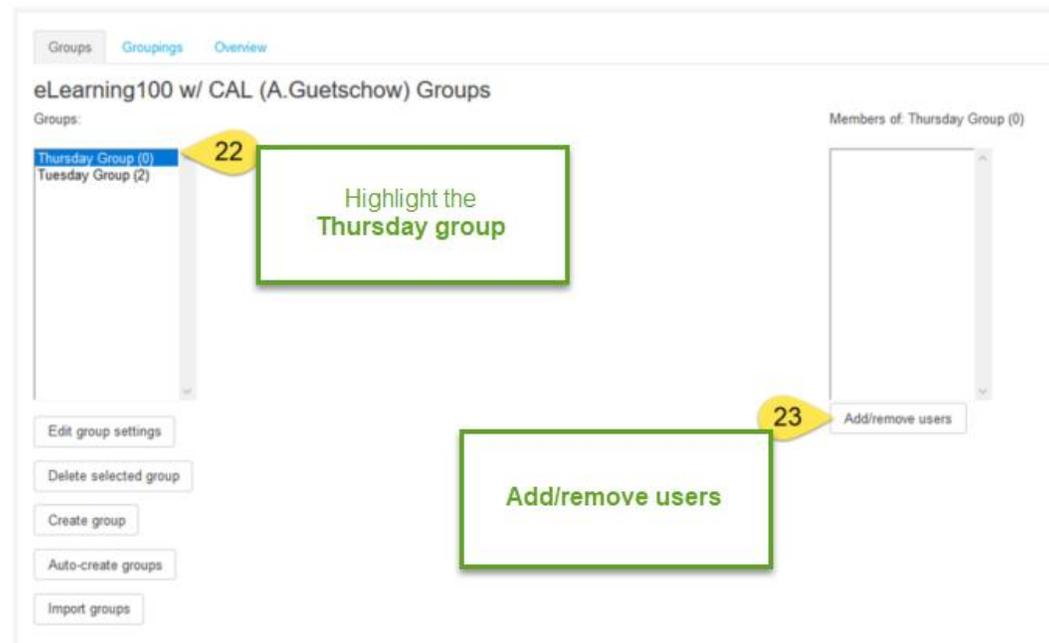
Modality Principle = Audio explanations of visuals lead to better learning than text explanations of visuals.

Split Attention Principle = When two mutually dependent visual sources of information are laid out in a format that requires the learners to mentally integrate them.”

GOOD MULTIMEDIA EXAMPLE: In an e-learning lesson, the software screen is visible and an audio narration of the instructor describes how to perform a step while demonstrating the procedure in the application. The use of audio that describes the actions demonstrated in the application minimizes load for novice learners.



GOOD PRINT EXAMPLE: If the same procedure is being presented in a paper medium, words must be presented in text. An efficient example integrates the steps into a visual that shows the applications screens.



An **inefficient** example explains screen with words in text placed over or under the visual that requires the learner to expend extra mental effort to do the integration herself.”

22. Make sure you highlight the **Thursday group** in the **Groups:** box on the left.

23. Click **Add/remove users**.



How to Display Worked Examples.

“Audio narration is more transient than text. When using audio to describe a visual, we recommend that some form of visual cueing be used to draw the eye to the portion of the visual being described by the audio. Use a cueing device such as color, an arrow or subtle animation to draw attention to the portion of the visual being explained.

When using faded completion examples, present the example with integrated text rather than audio so the learner can refer to it as they finish it.”

The Bottom Line.

“There are solid research and psychological reasons for recommending that you:

- Help novice learners build robust schemas by pairing worked examples with practice assignments.
- Ensure that learners study worked examples by using completion examples.

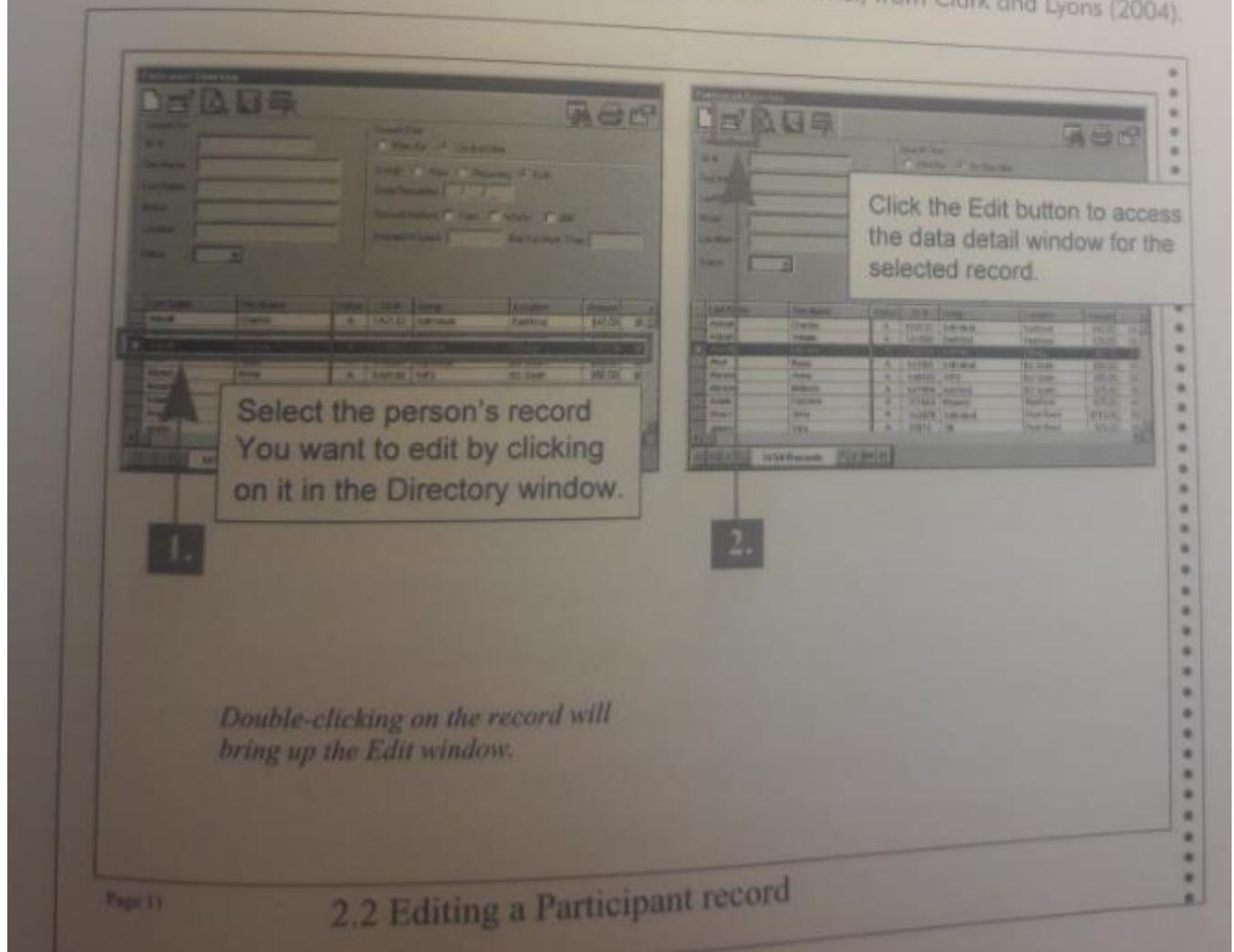
- Transition gradually from worked examples to full practice as learners gain expertise.
- Use backwards faded completion examples to full practice problems as learners gain expertise.
- Format worked examples in ways that manage cognitive load in multimedia through audio narration of steps and cueing of related visuals and in print media through integration of text nearby the visual.
- Format completion examples with text that is integrated into the visual to avoid split attention.”

Tips on Using Worked Examples to Impose Mental Work Gradually

- “If students need to practice a skill to build proficiency, use backwards faded worked examples.
- When working with subject-matter experts (SMEs) during course design, ask them to show you examples of how to complete the task in a step-by-step manner. Prepare for your session ahead by asking them to identify and bring task samples with them to your interview. As the SME describes how to complete the task, use audio recorders and cameras to document the steps and the visual interfaces.
- If the task involves spatial content, such as use of computer screens or equipment, minimize cognitive load in examples either by integrating words into the diagram or by using audio to present the words.
- Use audio to explain full worked examples and integrated text to explain faded completion examples.
- Because audio is transient, always provide a replay button so learners can repeat an example.
- If your task involves spatial content, design your screen or page real estate to accommodate the graphics and integrated text. Research shows that multiple visuals involved in a procedure can be effectively displayed in paper formats using the entire page spread. Note: I believe the “entire page spread” is referring to Figure 8.10, which shows steps 1 and 2 with their integrated text displayed on the same page (side-by-side screen shots).” [An image of Figure 8.10 follows]

Figure 8.10. A Print-Based Worked Example That Integrates Text into Diagram to Minimize Split Attention.

Source: Mark Palmer, from Clark and Lyons (2004).



Reference

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