reinforce a robust understanding of deep structures and underlying principles, provide sufficiently diverse contexts in which to apply these principles, and help students make appropriate connections between the knowledge and skills they possess and new contexts in which those skills apply. We consider some specific strategies under the heading, "Strategies to Facilitate Transfer," later in this chapter.

WHAT STRATEGIES DOES THE RESEARCH SUGGEST?

The following strategies include those faculty can use to (1) decompose complex tasks so as to build students' skills more systematically and to diagnose areas of weakness, (2) help students combine and integrate skills to develop greater automaticity and fluency, and (3) help students learn when to apply what they have learned.

Strategies to Expose and Reinforce Component Skills

Push Past Your Own Expert Blind Spot Because of the phenomenon of expert blind spot, instructors may have little conscious awareness of all the component skills and knowledge required for complex tasks. Consequently, when teaching students, instructors may inadvertently omit skills, steps, and information that students need in order to learn and perform effectively. To determine whether you have identified all the component skills relevant for a particular task, ask yourself: "What would students have to know—or know how to do—in order to achieve what I am asking of them?" Keep asking this question as you decompose the task until you have identified all the key component skills. Many instructors stop decomposing the task too soon and thus fail to identify critical component skills their students might lack.

Enlist a Teaching Assistant or Graduate Student to Help with Task Decomposition As experts in our disciplinary domains, we operate in a state of "unconscious competence" that can make it difficult to see the component skills and knowledge that students must acquire to perform complex tasks. Graduate students, on the other hand, tend to be at the "*conscious* competence" stage (see Sprague and Stewart's model as illustrated in Figure 4.2), and thus may be more aware than you are of the necessary component skills. Thus, it can be helpful to ask a teaching assistant or graduate student to help you decompose complex tasks.

Talk to Your Colleagues Another way to overcome expert blind spot is to compare notes with colleagues to see how *they* decompose complex tasks, such as research papers, oral presentations, or design projects. Although your colleagues have their own expert blind spots to overcome, they may have identified skills that you have not. Thus it can be helpful to talk with them and ask to examine their syllabi, assignments, and performance rubrics for ideas. (See Appendix C for information on rubrics.)

Enlist the Help of Someone Outside Your Discipline Also helpful when you are attempting to decompose a complex task is to ask someone outside your discipline to help you review your syllabus, lectures, assignments, and other teaching materials. A person (such as a teaching consultant or colleague outside your discipline) who is intelligent and insightful but does not share your disciplinary expertise *or* its blind spots can help you identify areas in which you may have inadvertently omitted or skipped over important component knowledge or skills.

Explore Available Educational Materials Many, though not all, of the component skills necessary for a particular task are specific to disciplinary context. Depending on your discipline, there may be published work that presents completed task analyses that can help you think about the component skills in your course. Check journals on teaching in your discipline.

Focus Students' Attention on Key Aspects of the Task If students are expending their cognitive resources on extraneous features of the task, it diverts those resources from the germane aspects of the task. Thus, one way to help students manage cognitive load is to clearly communicate your goals and priorities for particular assignments by telling students where to put their energies—and also where not to. For example, if you assign students in your architecture class a task meant to help them explore a wide range of creative design solutions, you might explicitly instruct them not to spend time getting the details right or making their designs aesthetically pleasing, but rather to generate as many different design solutions as possible. Rubrics that spell out your performance criteria for particular assignments can help students focus their cognitive resources where they best serve your learning objectives. (See Appendix C for more information on and examples of rubrics.)

Diagnose Weak or Missing Component Skills To assess your students' competence vis-à-vis component skills and knowledge, consider giving a diagnostic exam or assignment early in the semester (see Appendix A for information on developing student self-assessments). If a small number of students lack key skills, you can alert them to this fact and direct them to resources (academic support on campus, tutoring, additional readings) to help them develop these skills on their own. If a large number of students lack key prerequisite skills, you might opt to devote some class time to addressing them or hold an informal review session outside class. You can also assess your students' understanding of subject matter in your own course by analyzing the patterns of mistakes students make on exams, papers, oral presentations, and so on. The information you gain from these kinds of ongoing analyses can help you design instruction to reinforce critical skills, or improve the next iteration of the course.

Provide Isolated Practice of Weak or Missing Skills Once you have identified important missing skills, create opportunities (such as homework assignments or in-class activities) for students to practice those skills in relative isolation. For example, if students are writing conclusions to their papers that simply restate the topic paragraph or descend into banalities—and you perceive this as an obstacle to achieving one of your learning objectives—you might (1) ask students to read the conclusions of several articles and discuss what makes them compelling or not compelling, (2) have them write a conclusion for an article that is missing one, and (3) critique their conclusions together. Similarly, in a class focused on quantitative problem solving, you might ask students to plan a problem-solving strategy without actually carrying it out. This focuses their energies on one aspect of the task—planning—and builds that particular skill before allowing students to jump into calculations.

Strategies to Build Fluency and Facilitate Integration

Give Students Practice to Increase Fluency If diagnostic assessments, such as those described above, reveal that students can perform key component skills but they continue to do them inefficiently and with effort, you might want to assign exercises specifically designed to increase students' speed and efficiency. In a language class, for example, this might involve asking students to drill verb conjugations until they come easily. In a quantitative class, it might involve assigning supplementary problem-solving exercises to build automaticity in a basic mathematical skill—vector arithmetic, for example. When providing practice intended to increase automaticity, explain your rationale to your students. For example: "It is important not only that you can do these calculations, but also that you can do them quickly and easily, so that when you are solving a complex problem you do not get bogged down in the basic mathematical calculations. These exercises are to increase your efficiency." You should also be explicit about the level of fluency you expect students to achieve, as illustrated in these examples: "You should practice these to the point that you can solve an entire page of problems in less than fifteen minutes without the use of a calculator" or "You should be able to scan a thirty-page journal article and extract its main argument in less than five minutes."

Temporarily Constrain the Scope of the Task It can be helpful to minimize cognitive load temporarily while students develop greater fluency with component skills or learn to integrate them. One way to do this is by initially reducing the size or complexity of the task. For example, a piano teacher might ask students to practice only the right hand part of a piece, and then only the left hand part, before combining them. If the student still struggles to integrate the two parts successfully, the teacher might ask her to practice only a few measures, until she develops greater fluency at coordinating both hands. Similarly, a typography instructor might give an assignment early in the semester in which students must create a design using only font and font size but no other design elements. Once students have practiced these particular components, the instructor can then add additional elements, such as color or animations, adding to the level of complexity as students gain fluency in the component skills.

Explicitly Include Integration in Your Performance Criteria As we have seen, integration is a skill in itself. Thus, it is reasonable to include the effective integration of component parts in your performance rubrics for complex tasks. For example, on the rubric for a group project and presentation, you could include the seamless integration of every member's contribution to the project, or a consistent voice, as features of high-quality performance (see Appendix C for information on rubrics). Likewise, on an analytical paper, you could identify the coherence or "flow" of ideas as an important dimension of performance.

Strategies to Facilitate Transfer

Discuss Conditions of Applicability Do not assume that because students have learned a skill that they will automatically know where or when to apply it. It is important to clearly and explicitly explain the contexts in which particular skills are—or are not—applicable (for example, when one might collect qualitative versus quantitative data, use a T-test, or transcribe lines of dialogue phonetically). Of course, there will not always be a single "best" solution or approach, in which case it is helpful to ask students to discuss the pros and cons of different approaches (for example, "What objectives are and are not served by staging a play in a minimalist style?" or "What do you gain and lose by using a questionnaire instead of a face-to-face interview?"). Explicitly discussing the conditions and contexts of applicability can help students transfer what they know more successfully.

Give Students Opportunities to Apply Skills or Knowledge in Diverse Contexts When students practice applying skills across diverse contexts it can help them overcome context-dependence and prepare them better to transfer that skill to novel contexts. So when possible, give students opportunities to apply a particular skill (or knowledge) in multiple contexts. For example, if you are teaching students a set of marketing principles, you might assign multiple case studies to give students the opportunity to apply those principles in the context of very different industries.

Ask Students to Generalize to Larger Principles To increase the flexibility of knowledge and thus the likelihood of transfer, encourage students to generalize from specific contexts to abstract principles. You can do this by asking questions such as "What is the physical principle that describes what is happening here?" or "Which of the theories we have discussed is exemplified in this article?" Asking students to step back from the details of particular problems or cases and focus on larger principles can help them reflect on and, one hopes, transfer and adapt the skills they are learning to new contexts.

Use Comparisons to Help Students Identify Deep Features Students may fail to transfer knowledge or skills appropriately if they cannot recognize the meaningful features of the problem. Providing your students with structured comparisons—of problems, cases, scenarios, or tasks—helps them learn to differentiate the salient features of the problem from the surface characteristics. For example, in a physics class you might present two problems in which the surface features are similar (they both involve pulleys) but the physics principles at work are different (coefficient of friction versus gravity). Or you could present two problems in which the surface features are different (one involves a pulley and one involves an inclined plane) but the physics principle is the same. Structured comparisons such as these encourage students to identify and focus on underlying, structural similarities and differences and caution them not to be fooled by superficial features. This can then help them recognize the deep features of novel problems and thus facilitate successful transfer.

Specify Context and Ask Students to Identify Relevant Skills or Knowledge Help students make connections between problems they might confront and the skills and knowledge they possess by giving them a context—a problem, case, or scenario—and asking them to generate knowledge and skills (for instance, rules, procedures, techniques, approaches, theories, or styles) that are appropriate to that context. For example, "Here is a statistical problem; which of the tests you know could be used to solve it?" or "Here is an anthropological question you might want to investigate; what particular data-gathering methods could you use to answer it?" Then vary the context by asking "what if" questions, such as "What if this involved dependent variables? Could we still use this test?" or "What if the subjects of your research were children? Could you still employ that methodology?" It is not always necessary for students to *do* the actual application (apply the statistical test, conduct the ethnographic research) but rather to *think* about the features of the problem in relation to particular applications.

Specify Skills or Knowledge and Ask Students to Identify Contexts in Which They Apply To further help students make connections between skills and knowledge they possess and appropriate applications, turn the strategy described above around. In other words, specify a particular skill (for instance, a technique, formula, or procedure) or piece of knowledge (for example, a theory or rule) and ask students to generate contexts in which that skill or knowledge would apply. For example, "Give me three statistical problems that a T-test could help you solve" or "Here is a data-gathering method used in ethnographic research;

what questions could it be used to investigate?" Again, it is not necessary for students to do the actual application, but rather to think about the applicability of particular skills and knowledge to particular problems.

Provide Prompts to Relevant Knowledge Sometimes students possess skills or knowledge that are relevant to a new problem or situation but do not think to apply what they know. Small prompts to relevant knowledge and skills (such as "Where have we seen this style of brushwork before?" or "Would this concept be relevant to anything else we have studied?" or "Think back to the bridge example we discussed last week") can help students make connections that facilitate transfer. Over time, prompts from the instructor may become unnecessary as students learn to look for these connections on their own.

SUMMARY

In this chapter we have argued that in order to develop mastery, students must acquire a set of component skills, practice combining and integrating these components to develop greater fluency and automaticity, and then understand the conditions and contexts in which they can apply what they have learned. Students need to have these three elements of mastery taught and reinforced through practice. However, because instructors have often lost conscious awareness of these aspects of expert practice, they may inadvertently neglect them in their instruction. Consequently, it is of particular importance that instructors deliberately regain awareness of these elements of mastery so they can teach their students more effectively.