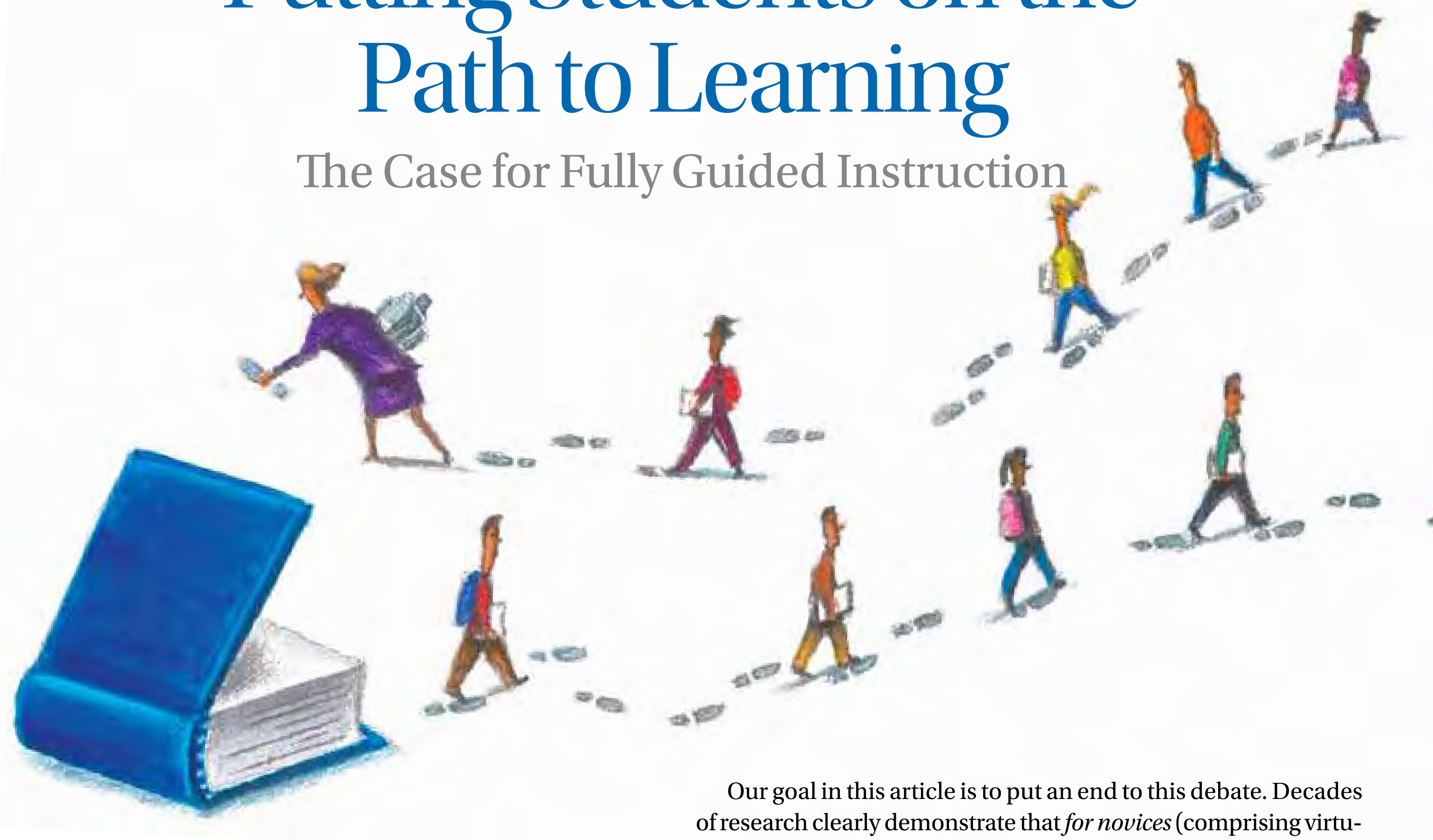
Putting Students on the Path to Learning

The Case for Fully Guided Instruction



By Richard E. Clark, Paul A. Kirschner, and John Sweller

Disputes about the impact of instructional guidance during teaching have been ongoing for more than a half century.[1] On one side of this argument are those who believe that all people—novices and experts alike—learn best when provided with instruction that contains unguided or partly guided segments. This is generally defined as instruction in which learners, rather than being presented with all essential information and asked to practice using it, must discover or construct some or all of the essential information for themselves.[2] On the other side are those who believe that ideal learning environments for experts and novices differ: while experts often thrive without much guidance, nearly everyone else thrives when provided with full, explicit instructional guidance (and should not be asked to discover any essential content or skills).[3]

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Our goal in this article is to put an end to this debate. Decades of research clearly demonstrate that *for novices* (comprising virtually all students), direct, explicit instruction is more effective and more efficient than partial guidance.[4] So, when teaching new content and skills to novices, teachers are more effective when they provide explicit guidance accompanied by practice and feedback, not when they require students to discover many aspects of what they must learn. As we will discuss, this does not mean direct, expository instruction all day every day. Small group and independent problems and projects can be effective—not as vehicles for making discoveries, but as a means of *practicing* recently learned content and skills.

Before we describe this research, let's clarify some terms. Teachers providing explicit instructional guidance *fully explain* the concepts and skills that students are required to learn. Guidance can be provided through a variety of media, such as lectures, modeling, videos, computer-based presentations, and realistic demonstrations. It can also include class discussions and activities—if the teacher ensures that through the discussion or activity, the relevant information is explicitly provided and practiced. In a math class, for example, when teaching students how to solve a new type of problem, the teacher may begin by showing students how to solve the problem and fully explaining the how and why of the mathematics involved. Often, in following problems, step-by-step explanations may gradually be faded or withdrawn until, through practice and feedback, the students can solve the problem themselves. In this way, before trying to solve the problem on their own, students would already have been walked through both the procedure and the concepts behind the procedure.

In contrast, those teachers whose lessons are designed to offer partial or minimal instructional guidance expect students to dis-

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cover on their own some or all of the concepts and skills they are supposed to learn. The partially guided approach has been given various names, including discovery learning,[5] problem-based learning,[6] inquiry learning,[7] experiential learning,[8] and constructivist learning.[9] Continuing the math example, students receiving partial instructional guidance may be given a new type of problem and asked to brainstorm possible solutions in small groups with or without prompts or hints. Then there may be a class discussion of the various groups' solutions, and it could be quite some time before the teacher indicates which solution is correct. Through the process of trying to solve the problem and discussing different students' solutions, each student is supposed to discover the relevant mathematics. (In some minimal guidance classrooms, teachers use explicit instruction of the solution as a backup method for those students who did not make the necessary discoveries and who were confused during the class discussion.) Additional examples of minimally guided approaches include (1) inquiry-oriented science instruction in which students are expected to discover fundamental principles by mimicking the investigatory activities of professional researchers,[10] and (2) medical students being expected to discover well-established solutions for common patient problems.[11]

Two bodies of research reveal the weakness of partially and minimally guided approaches: research comparing pedagogies, and research on how people learn. The past half century of empirical research has provided overwhelming and unambiguous evidence that, for everyone but experts, partial guidance during instruction is significantly less effective and efficient than full guidance. And, based on our current knowledge of how people learn, there is no reason to expect that partially guided instruction in K–12 classrooms would be as effective as explicit, full guidance.

I. Research Comparing Fully Guided and Partially Guided Instruction

Controlled experiments almost uniformly indicate that when dealing with novel information (i.e., information that is new to learners), students should be explicitly shown what to do and how to do it, and then have an opportunity to practice doing it while receiving corrective feedback.[12] A number of reviews of empirical studies on teaching novel information have established a solid research-based case against the use of instruction with minimal guidance. Although an extensive discussion of those studies is outside the scope of this article, one recent review is worth noting: Richard Mayer (a cognitive scientist at the University of California, Santa Barbara) examined evidence from studies conducted from 1950 to the late 1980s comparing pure discovery learning (defined as unguided, problem-based instruction) with guided forms of instruction.[13] He suggested that in each decade since the mid-1950s, after empirical studies provided solid evidence that the then-popular unguided approach did not work, a similar approach soon popped up under a different name with the cycle repeating itself. Each new set of advocates for unguided approaches seemed unaware of, or uninterested in, previous evidence that unguided approaches had not been validated. This pattern produced discovery learning, which gave way to experi-

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ential learning, which gave way to problem-based and inquiry learning, which has recently given way to constructivist instructional techniques. Mayer concluded that the "debate about discovery has been replayed many times in education, but each time, the research evidence has favored a guided approach to learning."[14] (To learn about these effective guided approaches, please see the companion article by Barak Rosenshine that begins on page 12.)

Evidence from well-designed, properly controlled experimental studies from the 1980s to today also supports direct instructional guidance.[15] Some researchers[16] have noted that when students learn science in classrooms with pure-discovery methods or with minimal feedback, they often become lost and frustrated, and their confusion can lead to misconceptions. Others[17] found that because false starts (in which students pursue misguided hypotheses) are common in such learning situations, unguided discovery is most often inefficient. In a very important study, researchers not only tested whether science learners learned more via discovery, compared with explicit instruction, but also, once learning had occurred, whether the quality of learning differed.[18] Specifically, they tested whether those who had learned through discovery were better able to transfer their learning to new contexts (as advocates for minimally guided approaches often claim). The findings were unambiguous. Direct instruction involving considerable guidance, including examples, resulted in vastly more learning than discovery. Those relatively few students who learned via discovery showed no signs of superior quality of learning.

In real classrooms, several problems occur when different kinds of minimally guided instruction are used. First, often only the brightest and most well-prepared students make the discovery. Second, many students, as noted above, simply become frustrated. Some may disengage, others may copy whatever the brightest students are doing—either way, they are not actually discovering anything. Third, some students believe they have discovered the correct information or solution, but they are mistaken and so they learn a misconception that can interfere with later learning and problem solving.[19] Even after being shown the right answer, a student is likely to recall his or her discovery—not the correction. Fourth, even in the unlikely event that a problem or project is devised that all students succeed in completing,

minimally guided instruction is much less efficient than explicit guidance. What can be taught directly in a 25-minute demonstration and discussion, followed by 15 minutes of independent practice with corrective feedback by a teacher, may take several class periods to learn via minimally guided projects and/or problem solving.

As if these four problems were not enough cause for concern, there is one more problem that we must highlight: *minimally guided instruction can increase the achievement gap*. A review[20] of approximately 70 studies, which had a range of more- and less-skilled students as well as a range of more- and less-guided instruction, found the following: more-skilled learners tend to learn more with less-guided instruction, but less-skilled learners tend to learn more with more-guided instruction. Worse, a number of experiments found that less-skilled students who chose or were assigned to less-guided instruction received significantly *lower* scores on posttests than on pretest measures. For these relatively weak students, the failure to provide strong instructional support produced a *measurable loss of learning*. The implication of these results is that teachers should provide explicit instruction when introducing a new topic, but gradually fade it out as knowledge and skill increase.

Even more distressing is evidence[21] that when learners are asked to select between a more-guided or less-guided version of the same course, less-skilled learners who choose the less-guided approach tend to like it even though they learn less from it. It appears that guided instruction helps less-skilled learners by providing task-specific learning strategies. However, these strategies require learners to engage in explicit, attention-driven effort and so tend not to be liked, even though they are helpful to learning.

Similarly, more-skilled learners who choose the more-guided version of a course tend to like it even though they too have selected the environment in which they learn less. The reason more guidance tends to be less effective with these learners is that, in most cases, they have already acquired task-specific learning strategies that are more effective for them than those embedded in the more-guided version of the course. And some evidence suggests that they like more guidance because they believe they will achieve the required learning with minimal effort.

If the evidence against minimally guided approaches is so strong, why is this debate still alive? We cannot say with any certainty, but one major reason seems to be that many educators mistakenly believe partially and minimally guided instructional approaches are based on solid cognitive science. Turning again to Mayer's review of the literature, many educators confuse "constructivism," which is a theory of how one learns and sees the world, with a prescription for how to teach.[22] In the field of cognitive science, constructivism is a widely accepted theory of learning; it claims that learners must construct mental representations of the world by engaging in active cognitive processing. Many educators (especially teacher education professors in colleges of education) have latched on to this notion of students having to "construct" their own knowledge, and have *assumed* that the best way to promote such construction is to have students try to discover new knowledge or solve new problems without explicit guidance from the teacher. Unfortunately, this assumption is both widespread and incorrect. Mayer calls it the "constructivist teaching fallacy." Simply put, cognitive activity can happen with or without behavioral activity, and behavioral activity does not in any way guarantee cognitive activity. In fact, the type of active cognitive processing that students need to engage in to "construct" knowledge can happen through reading a book, listening to a lecture, watching a teacher conduct an experiment while simultaneously describing what he or she is doing, etc. Learning requires the construction of knowledge. Withholding information from students does not facilitate the construction of knowledge.

II. The Human Brain: Learning 101

In order to really comprehend why full instructional guidance is more effective and efficient than partial or minimal guidance for novices, we need to know how human brains learn. There are two essential components: long-term memory and working memory (often called short-term memory). Long-term memory is that big mental warehouse of things (be they words, people, grand philosophical ideas, or skateboard tricks) we know. Working memory is a limited mental "space" in which we think. The relations between working and long-term memory, in conjunction with the cognitive processes that support learning, are of critical importance to developing effective instruction.

Our understanding of the role of long-term memory in human cognition has altered dramatically over the last few decades. It is no longer seen as a passive repository of discrete, isolated fragments of information that permit us to repeat what we have learned. Nor is it seen as having only peripheral influence on complex cognitive processes such as critical thinking and problem solving. Rather, long-term memory is now viewed as the central, dominant structure of human cognition. Everything we see, hear, and think about is dependent on and influenced by our long-term memory.

A seminal series of studies[23] on chess players, for example, demonstrated that expert players perform well even in "blitz" games (which are played in five minutes) because they are not actually puzzling through each move. They have tens of thousands of board configurations, and the best move for each configuration, stored in long-term memory. Those configurations are learned by studying previous games for 10 years or more. Expert players can play well at a fast pace because all they are doing is recalling the best move—not figuring it out. Similar studies of how experts function have been conducted in a variety of other areas.[24] Altogether, the results suggest that expert problem solvers derive their skill by drawing on the extensive experience stored in their long-term memory in the form of concepts and procedures, known as mental schemas. They retrieve memories of past procedures and solutions, and then quickly select and apply the best ones for solving problems. We are skillful in an area if our long-term memory contains huge amounts of information or knowledge concerning the area. That information permits us to quickly recognize the characteristics of a situation and indicates to us, often immediately and unconsciously, what to do and when to do it. (For instance, think about how much easier managing student behavior was in your fifth year of teaching than in your first year of teaching.) Without our huge store of information in long-term memory, we would be largely incapable of everything from simple acts such as avoiding traffic while crossing a street (information many other animals are unable to store in their long-term memory), to complex activities such as playing chess, solving mathematical problems, or keeping students' attention. In short, our long-term memory incorporates a massive knowledge base that is central to all of our cognitively based activities.

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What are the instructional consequences of long-term memory? First and foremost, long-term memory provides us with the ultimate justification for instruction: the aim of all instruction is to add knowledge and skills to long-term memory. If nothing has been added to long-term memory, nothing has been learned.

Working memory is the cognitive structure in which conscious processing occurs. We are only conscious of the information currently being processed in working memory and are more or less oblivious to the far larger amount of information stored in long-term memory. When processing novel information, working memory is very limited in duration and capacity. We have known at least since the 1950s that almost all information stored in working memory is lost within 30 seconds[25] if it is not rehearsed and that the capacity of working memory is limited to only a very small number of elements.[26] That number is usually estimated at about seven, but may be as low as four, plus or minus one.[27] Furthermore, when processing (rather than merely storing) information, it may be reasonable to conjecture that the number of items that can be processed may only be two or three, depending on the nature of the processing required.

For instruction, the interactions between working memory and long-term memory may be even more important than the processing limitations.[28] The limitations of working memory only apply to new, to-be-learned information (that has not yet been stored in long-term memory). When dealing with previously learned, organized information stored in long-term memory, these limitations disappear. Since information can be brought back from long-term memory to working memory as needed, the 30-second limit of working memory becomes irrelevant. Similarly, there are no known limits to the amount of such information that can be brought into working memory from long-term memory.

These two facts—that working memory is very limited when dealing with novel information, but that it is not limited when dealing with organized information stored in long-term memory—explain why partially or minimally guided instruction typically is ineffective for novices, but can be effective for experts. When given a problem to solve, novices' only resource is their very constrained working memory. But experts have both their working memory and all the relevant knowledge and skill stored in long-term memory.

One of the best examples of an instructional approach that takes into account how our working and long-term memories interact is the "worked-example effect." A worked example is just what it sounds like: a problem that has already been solved (or "worked out") for which every step is fully explained and clearly shown; it constitutes the epitome of direct, explicit instruction.*

*For a short YouTube video of a worked example, go to http://bit.ly/xa0TYQ and see Shaun Errichiello, who teaches seventh-grade math at the Salk School of Science (M.S. 225) in New York City, work through a word problem with fractions.

The "worked-example effect" is the name given to the widely replicated finding that novice learners who try to learn by being required to solve problems perform worse on subsequent test problems, including transfer problems different from the ones seen previously, than comparable learners who learn by studying equivalent worked examples.

The worked-example effect was first demonstrated in the 1980s.[29] Researchers found that algebra students learned more by studying worked examples than by solving equivalent problems. Since those early demonstrations of the effect, it has been replicated on numerous occasions using a large variety of learners studying an equally large variety of materials—from mathematics and science to English literature and world history.[30] For novices, studying worked examples seems invariably superior to discovering or constructing a solution to a problem.

Why does the worked-example effect occur? The limitations of working memory and the relations between working memory and long-term memory discussed earlier can explain it. Solving a problem requires searching for a solution, which must occur using our limited working memory. If the learner has no relevant concepts or procedures in long-term memory, the only thing to do is blindly search for possible solution steps that bridge the gap between the problem and its solution. This process places a great burden on working-memory capacity because the problem solver has to continually hold and process the current problem state in working memory (e.g., Where am I right now in the problem-solving process? How far have I come toward finding a solution?) along with the goal state (e.g., Where do I have to go? What is the solution?), the relations between the goal state and the problem state (e.g., Is this a good step toward solving the problem? Has what I've done helped me get nearer to where I need to go?), the solution steps that could further reduce the differences between the two states (e.g., What should the next step be? Will that step bring me closer to the solution? Is there another solution strategy I can use that might be better?), and any subgoals along the way. Thus, searching for a solution overburdens limited working memory and diverts working-memory resources away from storing information in long-term memory. As a consequence, novices can engage in problem-solving activities for extended periods and learn almost nothing.[31]

In contrast, studying a worked example* reduces the burden on working memory (because the solution only has to be comprehended, not discovered) and directs attention (i.e., directs working-memory resources) toward storing the essential relations between problem-solving moves in long-term memory. Students learn to recognize which moves are required for particular problems, which is the basis for developing knowledge and skill as a problem solver.[33]

It is important to note that this discussion of worked examples applies to novices—not experts. In fact, the worked-example effect first disappears and then *reverses* as the learners' expertise increases. That is, for experts, solving a problem is more effective than studying a worked example. When learners are sufficiently experienced, studying a worked example is a redundant activity that places a greater burden on working memory than retrieving a known solution from long-term memory.[34] This reversal in effectiveness is not limited to worked examples; it's true of many explicit, fully guided instructional approaches and is known as the "expertise reversal effect."[35] In general, the expertise reversal effect states that "instructional techniques that are highly effective with inexperienced learners can lose their effectiveness and even have negative consequences when used with more experienced learners."[36] This is why, from the very beginning of this article, we have emphasized that guidance is best for teaching *novel* information and skills. This shows the wisdom of instructional techniques that begin with lots of guidance and then fade that guidance as students gain mastery. It also shows the wisdom of using minimal guidance techniques to reinforce or practice previously learned material.

Recommending partial or minimal guidance for novices was understandable back in the early 1960s, when the acclaimed psychologist Jerome Bruner[37] proposed discovery learning as an instructional tool. At that time, researchers knew little about working memory, long-term memory, and how they interact. We now are in a quite different environment; we know much more about the structures, functions, and characteristics of working memory and long-term memory,

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*This assumes that the worked example is well designed. It is possible, if one is not careful, to structure a worked example in a manner that places a large burden on working memory. Indeed, it is possible to structure worked examples that impose as heavy a cognitive load as the problem-solving search required to learn via discovery.[32]

the relations between them, and their consequences for learning, problem solving, and critical thinking. We also have a good deal more experimental evidence as to what constitutes effective instruction: controlled experiments almost uniformly indicate that when dealing with novel information, learners should be explicitly shown all relevant information, including what to do and how to do it. We wonder why many teacher educators who are committed to scholarship and research ignore the evidence and continue to encourage minimal guidance when they train new teachers.

After a half century of advocacy associated with instruction using minimal guidance, it appears that there is no body of sound research that supports using the technique with anyone other than the most expert students. Evidence from controlled, experimental (a.k.a. "gold standard") studies almost uniformly supports full and explicit instructional guidance rather than partial or minimal guidance for novice to intermediate learners. These findings and their associated theories suggest teachers should provide their students with clear, explicit instruction rather than merely assisting students in attempting to discover knowledge themselves. □

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