EDUCATIONAL PSYCHOLOGIST, *42*(2), 99–107

Scaffolding and Achievement in Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller, and Clark (2006)

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Many innovative approaches to education such as problem-based learning (PBL) and inquiry learning (IL) situate learning in problem-solving or investigations of complex phenomena. Kirschner, Sweller, and Clark (2006) grouped these approaches together with unguided discovery learning. However, the problem with their line of argument is that IL and PBL approaches are highly scaffolded. In this article, we first demonstrate that Kirschner et al. have mistakenly conflated PBL and IL with discovery learning. We then present evidence demonstrating that PBL and IL are powerful and effective models of learning. Far from being contrary to many of the principles of guided learning that Kirschner et al. discussed, both PBL and IL employ scaffolding extensively thereby reducing the cognitive load and allowing students to learn in complex domains. Moreover, these approaches to learning address important goals of education that include content knowledge, epistemic practices, and soft skills such as collaboration and self-directed learning.

WHY PROBLEM-BASED AND INQUIRY LEARNING ARE NOT MINIMALLY GUIDED: ON ASSUMPTIONS AND EVIDENCE

All learning involves knowledge construction in one form or another; it is therefore a constructivist process. The question of what sorts of instructional practices are likely to promote such knowledge construction, or learning, is at the core of the argument presented by Kirschner, Sweller, and Clark (2006). The authors loosely define minimally guided instruction as a learning context in which "learners, rather than being presented with essential information, must discover or construct essential information for themselves" (p. 1). They conversely define direct guidance instruction as "providing information that fully explains the concepts and procedures that students are required to learn." In their argument, Kirschner et al. contrast minimally guided instructional approaches with approaches that provide direct instructional guidance and assert that minimally guided instructional approaches are ineffective and inefficient.

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There are two major flaws with Kirschner et al's argument. The first is a pedagogical one. Kirschner and colleagues have indiscriminately lumped together several distinct pedagogical approaches—constructivist, discovery, problem-based, experiential, and inquiry-based—under the category of minimally guided instruction. We argue here that at least some of these approaches, in particular, problem-based learning (PBL) and inquiry learning (IL), are not minimally guided instructional approaches but rather provide extensive scaffolding and guidance to facilitate student learning.

The second is a flaw in their evidentiary base. The claim by Kirschner et al. that approaches such as PBL and IL are ineffective is contrary to empirical evidence that indeed does support the efficacy of PBL and IL as instructional approaches. This evidence suggests that these approaches can foster deep and meaningful learning as well as significant gains in student achievement on standardized tests.

In our article we will discuss how PBL and IL provide instructional guidance and provide evidence that supports the efficacy of these pedagogical approaches. We will examine the claims of Kirschner et al. specifically in the context of PBL and IL, as these approaches clearly provide scaffolding for student learning. We begin with a brief discussion of the qualities of some of the pedagogical approaches

Kirschner et al. have included under their “minimally guided” umbrella.

ARE PBL AND IL INSTANCES OF MINIMALLY GUIDED INSTRUCTION?

Constructivist theories of learning stress the importance of learners being engaged in constructing their own knowledge (Mayer, 2004; Palincsar, 1998). An assumption that leads to the minimally guided discovery approach is that the learners need to explore phenomena and/or problems without any guidance. This assumption has been repeatedly demonstrated to be flawed (Mayer, 2004). We agree with Kirschner et al. (2006) that there is little evidence to suggest that unguided and experientially-based approaches foster learning. However, IL and PBL are not discovery approaches and are not instances of minimally guided instruction, contrary to the claims of Kirschner et al. Rather, PBL and IL provide considerable guidance to students.

Before we discuss the ways in which PBL and IL are not minimally guided, we begin by clarifying what is meant by PBL and IL. In PBL, students learn content, strategies, and self-directed learning skills through collaboratively solving problems, reflecting on their experiences, and engaging in self-directed inquiry. In IL, students learn content as well as discipline-specific reasoning skills and practices (often in scientific disciplines) by collaboratively engaging in investigations. Both PBL and IL are organized around relevant, authentic problems or questions. Both place heavy emphasis on collaborative learning and activity. In both, students are cognitively engaged in sense making, developing evidence-based explanations, and communicating their ideas. The teacher plays a key role in facilitating the learning process and may provide content knowledge on a just-in-time basis.

The major distinction that we perceive between PBL and IL is their origins. PBL has its origins in medical education and is based on research on medical expertise that emphasized a hypothetical-deductive reasoning process (Barrows & Tamblyn, 1980). PBL often uses text-based resources for both the problem data and self-directed learning. IL has its origins in the practices of scientific inquiry and places a heavy emphasis on posing questions, gathering and analyzing data, and constructing evidence-based arguments (Kuhn, Black, Keselman, & Kaplan, 2000; Krajcik & Blumenfeld, 2006).

As we have examined the broad variety of instantiations of PBL and IL, we have not uncovered any dimensions that consistently distinguish between PBL and IL. Indeed, we think there are no clear-cut distinguishing features. PBL frequently engages students in explorations and analyses of data, such as one would expect IL environments to do, and IL frequently poses problems and asks students to consult various resources to solve them as PBL environments do. For example, problems in medical PBL present students with rich sets of patient data to analyze (Barrows, 2000; Hmelo-Silver, 2004). Similarly, IL environments such as the Web Integrated Science Environment (WISE) provide students with scientific problems and the research materials that students examine in order to reach a conclusion about the problem (Linn & Slotta, 2006). Students may read a variety of resources in addition to reading about data and conducting their own studies. Thus, in practice PBL and IL environments are often indistinguishable, despite divergent origins and so we treat them as synonymous in this article.

As we have noted, PBL and IL environments are not minimally guided because of many forms of scaffolding provided. Moreover, these approaches may include direct instruction as one of the strategies they employ (Krajcik, Czerniak, & Berger, 1999; Schmidt, 1983; Schwartz & Bransford, 1998). However, in these contexts, direct instruction may be provided on a just-in-time basis and generally once students experience a need to know the information presented (Edelson, 2001). Thus a mini-lecture or benchmark lesson presenting key information to students is used when students understand the necessity of that information and its relevance to their problem-solving and investigational practices. Such just-in-time direct instruction promotes knowledge construction in a way that makes knowledge available for future use in relevant contexts (Edelson, 2001).

There is an extensive body of research on scaffolding learning in inquiry- and problem based environments (Collins, Brown, & Newman, 1989; Davis & Linn, 2000; Golan, Kyza, Reiser, & Edelson, 2002; Guzdial, 1994; Jackson, Stratford, Krajcik, & Soloway, 1994; Reiser, 2004; Toth, Suthers, & Lesgold, 2002), and researchers have developed theory-driven and empirically based design guidelines for incorporating effective scaffolding strategies to support learning (Hmelo & Guzdial, 1996; Hmelo-Silver, 2006; Quintana et al., 2004; Reiser et al., 2001).

Scaffolded inquiry and problem-based environments present learners with opportunities to engage in complex tasks that would otherwise be beyond their current abilities. Scaffolding makes the learning more tractable for students by changing complex and difficult tasks in ways that make these tasks accessible, manageable, and within student’s zone of proximal development (Rogoff, 1990; Vygotsky, 1978). Quintana et al. (2004) conceived of scaffolding as a key element of cognitive apprenticeship, whereby students become increasingly accomplished problem-solvers given structure and guidance from mentors who scaffold students through coaching, task structuring, and hints, without explicitly giving students the final answers. An important feature of scaffolding is that it supports students’ learning of both how to do the task as well as why the task should be done that way (Hmelo-Silver, 2006).

Scaffolding not only guides learners through the complexities of the task, it may also problematize important aspects of students’ work in order to force them to engage with key disciplinary frameworks and strategies (Reiser, 2004). Such scaffolds act by “rocking the boat” and stopping mindless progress through the task, thus redirecting students' attention to important learning goals such as examining counter claims, articulating explanations and reflecting on progress.

Scaffolding is often distributed in the learning environment, across the curriculum materials or educational software, the teachers or facilitators, and the learners themselves (Puntambekar & Kolodner, 2005). Teachers play a significant role in scaffolding mindful and productive engagement with the task, tools, and peers. They guide students in the learning process, pushing them to think deeply, and model the kinds of questions that students need to be asking themselves, thus forming a cognitive apprenticeship (Collins et al., 1989; Hmelo-Silver & Barrows, 2006). In the next sections, we consider how scaffolding is implemented in PBL and IL environments.

The Use of Scaffolding in PBL and IL

PBL and IL situate learning in complex tasks. Such task require scaffolding to help students engage in sense making, managing their investigations and problem-solving processes, and encouraging students to articulate their thinking and reflect on their learning (Quintana et al., 2004). These aspects of IL and PBL tasks are challenging for students in many ways, and different researchers aiming to help learners overcome these conceptual and practical hurdles have used several scaffolding strategies (e.g., Chinn, 2006; Guzdial, 1994; Jackson et al., 1996; Linn, Bell, & Davis, 2004; Reiser et al., 2001). Due to space considerations, we will only discuss a few of these strategies that highlight the ways in which scaffolding can reduce cognitive load, provide expert guidance, and help students acquire disciplinary ways of thinking and acting. All these strategies can support sense making, process management, and articulation and reflection. The examples we present provide a stark contrast to the Kirschner and colleagues' argument that inquiry and PBL environments provide minimal guidance and therefore increase cognitive load.

Scaffolding That Makes Disciplinary Thinking and Strategies Explicit

In PBL and IL environments facilitators and teachers make key aspects of expertise visible through questions that scaffold student learning by modeling, coaching, and eventually fading some of their support. Student learning occurs as students collaboratively engage in constructive processing. For example, in studying an expert PBL teacher in the context of medical education, Hmelo-Silver and Barrows (2006) showed that the teacher frequently pushed students to explain their thinking to help them build a causal explanation or identify the limits of their knowledge. This helps support students in sense making and in articulating their ideas.

IL and PBL environments also make disciplinary strategies explicit in students' interactions with the tasks and tools as well as the artifacts they create (Quintana et al., 2004). For example, in the scaffolded software tool for analyzing animal behavior, *Animal Landlord*, students create a chronological "storyboard" of the behavioral components they identify in a short video clip of animal behavior. In creating this storyboard students are expected to identify behavioral components, label them, and annotate their observations and interpretations about these components. This artifact makes salient the disciplinary strategies of analyzing animal behavior which include decomposing complex behavior into its constituents, categorizing the constituents, and interpreting their significance (Golan et al., 2001; Smith & Reiser, 1998). In addition to providing an investigation model for student to emulate, this also supports students' sense making and reflection.

Many other environments provide students with: (a) prompts to use particular reasoning strategies (e.g., Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel, 2006; White & Frederiksen, 1998); (b) structures for students to follow or fill in, such as filling in argument diagrams to learn to distinguish between claims and reasons (Bell, 2002; Toth et al., 2002) or templates for domain-specific explanations (Duncan, 2006; Sandoval & Reiser, 2004); and (c) models of expert performance for students to emulate (Chinn et al., 2000; Loh et al., 2001). Chinn and Hung (2007) demonstrated the effectiveness of expert models in promoting seventh graders' scientific reasoning. In a curriculum centered on argumentation about the interpretation of scientific studies, students in some classrooms were presented with models of children discussing how to evaluate the methodology of studies with scientists. The participants in these short discussions engaged in argumentative give and take about the strengths and weaknesses of studies. Students who received these models of effective argumentation demonstrated more individual progress than students who engaged in the same argumentation-based learning activities without the models. The models scaffolded students' reasoning by showing dialogic instances of expert reasoning.

Scaffolds That Embed Expert Guidance

In many IL and PBL environments, expert information and guidance is sometimes offered directly to the learner. For example in WISE, students are provided with expert's hints and explanations of the rationale underlying the processes students engage in (Davis, 2003). In some cases, such as goal-based scenarios (Schank & Cleary, 1995), expert information is offered directly to the learner through "conversations" with experts in the form of embedded video clips.

Schwartz and Bransford (1998) showed that providing explanations when needed can be a very effective form of scaffolding (see also Minstrell & Stimpson, 1996). Schwartz and Bransford presented some students with a lecture on memory after they had tried to explain the pattern of results in data from real memory experiments. Other students received the lecture without having engaged in the inquiry activity. The students who received the lecture after trying to explain the data learned much more from the lecture. In the context of students trying to explain data, the lecture provided scaffolding that helped students make sense of the data, and hence was more meaningful than the same lecture presented not as scaffolding for inquiry but as direct instruction.

In PBL in medical education, the facilitator models a hypothetical-deductive reasoning process (Hmelo-Silver & Barrows, 2006). In STELLAR PBL, an adaptation of PBL to teacher education, preservice teachers use video cases of expert teachers as models for adapting instructional plans (Derry et al., 2006). In addition, the video cases are linked to appropriate concepts in a learning sciences hypermedia. The indexing of the video to the hypermedia is another form of expert guidance.

Scaffolds That Structure Complex Tasks or Reduce Cognitive Load

A great deal of structure is provided through scaffolds in the IL and PBL environments. In PBL, structure is provided through whiteboards that communicate a problem-solving process as well through the human facilitator (Barrows, 2000; Hmelo-Silver, 2004). For example, the whiteboard provides columns for the group to keep track of the *facts* of the case, their evolving *hypotheses*, the *learning issues*, which are concepts that the group needs to learn more about in order to solve the problem, and an *action* plan, which helps remind the group of what they need to do. Maintaining the whiteboard is a part of the PBL process and becomes a routine that helps support intellectual discourse. Such routines provide predictable ways to move through activity structures, set social norms for participation and use of resources, and foster interaction (Leinhardt & Steele, 2005). Because these routines become automated, the PBL routine itself reduces cognitive demands. Although there is initial adaptation required, students quickly learn that they need to take on particular roles and to work together to identify the important facts of the problem, generate potential ideas about the problems, and what they need to learn about in order to solve the problem.

Scaffolding can also guide instruction and decrease cognitive load by structuring a task in ways that allow the learner to focus on aspects of the task that are relevant to the learning goals (Hmelo-Silver, 2006; Salomon, Perkins, & Globerson, 1991). For example, scaffolding can reduce cognitive load by automating the generation of data representations, labor intensive calculations, or storing information. By structuring the tasks and the available functionality (e.g., in computer-based environments), scaffolding can restrict the options that are available to the learner at any point in time to make the task accessible and manageable (Quintana et al., 2004). For example in Model-It, a software environment that allows students to build object-based models of natural phenomena (such as the effects of pollutants on a stream ecosystem), there are three functional modes: plan, build, and test (Jackson et al., 1996). The software restricts the options available to students such that students may only proceed to the build stage after they have planned their models, and they may not test it until they have identified some of the important objects and relationships in the system. Model-It further scaffolds students by allowing them to qualitatively express complex mathematical relationships as the software converts their verbally stated relationships into mathematical formulas used for running the model, thereby reducing cognitive load and situating the task within the learner's zone of proximal development.

In summary, many of the types of scaffolding described provide very strong forms of guidance that seem to us to be indistinguishable from some of the forms of guidance recommended by Cognitive Load theorists. We fail to see that the instruction recommended by Kirschner et al. differs so clearly from instructional practices in IL methods. Kirschner et al. touted worked examples and process worksheets as effective methods of guided learning. But PBL and IL methods employ modeling that seems very similar to worked examples as well as scaffolds to guide inquiry that strongly resemble process worksheets (e.g., Kirschner & Erkens, 2006; White & Frederiksen, 1998). We think a close analysis of IL and PBL methods indicates that they are indeed strongly guided form of instruction. Studies showing that unguided or minimally guided instruction is inferior to direct instruction are simply irrelevant to most approaches implementing PBL or IL.

ARE PBL AND IL INFERIOR TO STRONGLY GUIDED FORMS OF INSTRUCTION?

It is important to consider learning outcomes as multifaceted. The goals of learning should include not only conceptual and procedural knowledge but also the flexible thinking skills and the epistemic practices of the domain that prepare students to be lifelong learners and adaptive experts (Bereiter & Scardamalia, 2006; Bransford, Brown, & Cocking, 2000; Sandoval & Reiser, 2004). But even on similar outcomes, PBL and IL often prove to be superior in studies of classroom-based instruction.

Evidence that PBL is Effective

Although Kirschner et al. (2006) report on several studies and meta-analyses of PBL, they overlooked other reviews that were more favorable to PBL. At around the same time as the Albanese and Mitchell (1993) and Berkson (1993) reviews that Kirschner et al. (2006) cited, there was a third meta-analysis conducted by Vernon and Blake (1993). This analysis found that medical students in PBL curricula performed slightly worse on tests of basic science knowledge but performed better on tests of clinical knowledge than traditional medical students. In a more recent meta-analysis of the effects of PBL, Dochy, Segers, Van den Bossche, and Gijbels (2003) found there was no effect of PBL on declarative knowledge tests, but studies that compared PBL students with those in traditional curricula on measures of knowledge application showed a moderate effect size favoring PBL students.

Kirschner et al. cited the results of Patel, Groen, and Norman's (1993) research. In this study, students from very different universities with different entering characteristics were compared (and indeed there is a self-selection bias in most studies of PBL). They were compared at a single time on a single task, but the PBL students did indeed transfer the hypothesis-driven reasoning strategy they were taught to new problems whereas students in a traditional curriculum did not use this reasoning strategy. The PBL students were also more likely to make errors. But a close examination of these results reveals that although the PBL students made more errors, they also created more elaborated explanations compared to the sparse explanations of students in the traditional curriculum. Patel et al. concluded (and Kirschner et al. concurred) that PBL impedes the development of expert data-driven reasoning strategies. However, other research suggests that when faced with unfamiliar problems, experts go back to basic principles and effectively use hypothesis-driven reasoning rather than the data-driven reasoning used in familiar problems (Norman, Trott, Brooks, & Smith, 1994). In an experimental study comparing medical students trained to use either data-driven or hypothesis-driven[1] reasoning while learning about electrocardiograms, the hypothesis-driven reasoning strategy led to superior learning (Norman, Brooks, Colle, & Hatala, 2000).

The accuracy effect found in the Patel et al. study has not been a robust effect, as the Dochy et al.'s (2003) study suggests. A more recent longitudinal quasi-experimental study of first year medical students found that PBL students generated more accurate and coherent problem solutions than traditional medical students (Hmelo, 1998).

Although research at other grade levels and disciplines outside medicine is rare, there is other work that supports the positive effects of PBL. Derry et al. (2006) compared preservice teachers in the technology-supported STELLAR PBL course in educational psychology with students in other sections of educational psychology on a video analysis transfer task. Over three semesters of the class, there were consistently positive effects favoring the students in the PBL class on targeted outcomes. In a carefully controlled crossover study of MBA students, Capon and Kuhn (2004) randomly assigned students to either PBL-first, lecture-second or lecture-first, PBL-second condition for two different concepts. On measures of declarative knowledge, there were no differences between the conditions; however, the students constructed more integrative explanatory essays for the concepts that they had learned using a PBL approach.

[1]Data-driven and hypothesis-driven reasoning are also referred to as forward and backward reasoning, respectively.

PBL has been successfully applied at secondary education. In a study comparing traditional and problem-based instruction in high school economics, Mergendoller, Maxwell, and Bellisimo (2006) found that across multiple teachers and schools, students in the PBL course gained more knowledge than the students in a traditional course.

Another variant of PBL is anchored instruction, exemplified by the *Adventures of Jasper Woodbury* used in middle school mathematics (Cognition and Technology Group at Vanderbilt [CTGV], 1992). In a large-scale implementation study comparing students using the Jasper PBL instruction with matched comparison students across 16 school districts in 11 states, PBL had positive outcomes on standardized tests. On researcher-developed measures, the results showed no differences between PBL and traditional math instruction on single-step word problems but significant positive effects on solving multistep word problems and on other aspects of problem solving such as planning and problem comprehension for the PBL group.

The results reported here include fairly traditional measures of knowledge and knowledge application. It is important to note that the goals of PBL go beyond these kinds of measures. There is evidence that PBL supports the development of reasoning skills (e.g., Hmelo, 1998), problem-solving skills (e.g., CTGV, 1992; Gallagher, Stepien, & Rosenthal, 1992) and self-directed learning skills (e.g., Hmelo & Lin, 2000). PBL methods are also effective at preparing students from future learning. For instance, Schwartz and Martin (2004) found that ninth graders who initially learned through exploratory problem solving employing statistical principles learned more from a subsequent lecture than students who had initially learned from a worked example that the instructor explained in class.

Evidence for Effectiveness of IL Approaches

Kirschner and colleagues asserted that there is a lack of research using controlled experimentation which shows the relative effectiveness of IL methods. They presented evidence that lower-performing students assigned to minimally guided instruction showed a decrement in performance following such interventions. It is true that controlled experiments of inquiry-, project-, and problem-based environments are scarce. However, a few such studies do exist, and those show significant and marked effect sizes and gains in favor of inquiry-, problem-, and project-based environments (Geier et al, in press; Hickey, Kindfeld, Horwitz, & Christie, 1999; Hickey, Wolfe, & Kindfeld, 2000; Lynch, Kuipers, Pyke, & Szesze, 2005).

GenScope™ is an inquiry-based environment that has been extensively and systematically studied and has been shown to engender learning gains that are significantly larger than those attained in the comparison classrooms. The GenScope software is an open-ended inquiry environment designed to support high school students' investigations of genetic phenomena (Horwitz, Neumann, & Schwartz, 1996). Despite its exploratory and open-ended nature the GenScope environment scaffolds student learning in several complementary ways: (a) complex simulations make the causal mechanisms underlying genetic phenomena visible; (b) students can easily manipulate representations of biological entities at different biological organization levels; and (c) representations of the phenomena at the multiple levels are linked such that manipulations of one level have consequences (that students can see) at subsequent levels. Several iterations of the GenScope environment and related curriculum materials have been implemented in secondary classrooms and a validated assessment system was developed to evaluate student learning (Hickey et al., 2000).

Hickey et al. (1999) found that 381 students in 21 GenScope classrooms "showed significantly larger gains from pretest to posttest than the 107 students in 6 comparison classrooms." The largest gains were attained by students from general science and general biology classrooms (compared to honors and college prep classrooms). The mean performance of these students increased from the more basic forms of domain reasoning (cause-to-effects) to more sophisticated domain reasoning (effect-to-cause). This is contrary to Kirschner et al.'s argument that IL disadvantages weaker performing students.

Particularly impressive are the recent findings from a study by Geier et al. (in press), which shows significantly higher pass rates on high-stakes standardized exams for middle school students (Michigan Educational Assessment Program) in science classes that use inquiry-based materials compared to their peers in a large urban district in the Midwestern United States. This study involved two cohorts comprising 1,803 students in the intervention condition (in 18 schools) and 17,562 students in comparison schools over three years of enactment. The intervention included up to three inquiry units, each unit lasting between six and nine weeks of instruction and focused on concepts in physical sciences and ecology/earth science. These project-based units scaffolded learning using technology tools that expanded the types of questions students could investigate, the data they could collect and provided curricular support for model-building and scientific reasoning (Amati, Singer, & Carrillo, 1999; Schneider & Krajcik, 2002; Singer et al., 2000).

Geier et al. (in press) demonstrated that the observed gains occurred up to a year and a half after participation in inquiry-based instruction, and the effect was cumulative such that higher levels of participation (exposure to more inquiry-based units) resulted in higher gains. The high scores were attained in all three science content areas (earth, physical, and life) and both process skills (constructing and reflecting) assessed on the test. The effect sizes reported were 0.44 (14% improvement in total score) for students in the first cohort and 0.37 (13% overall improvement) for students in the larger second cohort. Thus, effect size was not appreciably reduced with the scale-up. Even more compelling is their finding that inquiry-based instruction was successful in reducing the achievement gap experienced by urban African-American boys. African-American boys in the inquiry classrooms "caught up" to and showed no statistically significant difference from girls after exposure to at least one inquiry-based unit.

Recent research by Lynch et al. (2005) also suggests that inquiry-based learning environments foster better engagement and mastery goal orientation among disadvantaged students. In their comparison study of over 2,000 eighth grade students (approximately 1,200 in the treatment and 1,000 in the comparison group) in ten middle schools in a large and diverse Maryland school district, Lynch et al. (2005) found overall higher gains for all diversity groupings (based on ethnicity, socioeconomic status, gender, and ESOL status) in the inquiry-based curriculum condition (a six to ten week unit in chemistry). Thus, inquiry students of all groups outperformed their comparison peers. The curriculum was also more effective (than traditional instruction) in increasing certain aspects of motivation and engagement, particularly among historically disadvantaged student groups.

There are other studies that we interpret as supporting the effectiveness of IL and other constructivist environments (e.g., Guthrie et al., 2004; Langer, 2001; Wu & Tsai, 2005). For example, Guthrie et al. found that an elementary school reading program that combined strategy instruction with enhanced student choice, ample hands-on experiences, and substantial student collaboration was more effective at advancing students' reading than either traditional instruction or a strategies-instruction-only treatment. We suspect that Kirschner et al. might claim that this study supports *their* position, because teachers who used the reading program provided students with guided instruction on strategies. If they did make this claim, they would only reinforce our central point. What Kirschner et al. view as effective instruction is often fully compatible with IL and other constructivist instruction. Most proponents of IL are in favor of structured guidance in an environment that affords choice, hands-on and minds-on experiences, and rich student collaborations.

In conclusion, there is growing evidence from large-scale experimental and quasi-experimental studies demonstrating that inquiry-based instruction results in significant learning gains in comparison to traditional instruction and that disadvantaged students benefit most from inquiry-based instructional approaches. In many or most cases, exemplars of IL instruction incorporate strong forms of guidance that proponents of guided instruction will find attractive.

Goals for Learning and Instruction

Kirschner et al. (2006) claimed that the pursuit of inquiry-based instructional methodologies has resulted in a shift of instructional focus "away from teaching a discipline as a body of knowledge towards an exclusive emphasis on learning a discipline by experiencing the processes and procedures of the discipline." This claim is problematic for at least two reasons. First, the change in instructional focus is not merely a result of inquiry methods of instruction but rather a much broader call for reform in the goals of education. Recent reform documents (AAAS, 1993; NCTM, 2000; NRC, 1996), in the United States as well as other countries (DFE/WO, 1995; Ministry of Education [Taiwan], 2001), have emphasized the importance of understanding not only content but also disciplinary epistemologies and investigative strategies. In the case of science education in particular, a large body of research supports the importance of understanding the nature of scientific research and the practices involved as a critical part of scientific literacy (e.g., DeBoer, 1991; Driver, Leach, Millar, & Scott, 1996; Duschl, 1990; Lederman, 1998; McComas, Clough, & Almazroa, 1998). This suggests broad goals for learning and instruction.

Second, current reforms and the inquiry approach are not substituting content for practices; rather, they advocate that content and practices are central learning goals. IL models do in fact foster rich and robust content learning (Shymansky, 1984; Wise & Okey, 1983; Von Secker & Lissitz, 1999). While it is challenging to develop instruction that fosters the learning of both the theoretical frameworks and investigative practices of a discipline, examples of such environments do exist (Linn, Bell, & Hsi, 1999; Reiser et al., 2001; White & Frederiksen, 1998), and recent design frameworks offer guidance for the development of such rich learning environments (Edelson, 2001; Quintana et al., 2004).

The notion that learning the concepts and theories of a discipline is best situated in the context of the practices of that discipline is supported by current theories of learning. Both situated and cognitivist perspectives on cognition recognize the influence of the learning context on the accessibility of the knowledge for future use (Collins, Brown, & Newman, 1989; Greeno, 2006; Kolodner, 1993; Schank, 1982). Given that students need to develop scientific understandings as interconnected, meaningful, and useful, it is imperative that the learning environments in which students acquire this knowledge be similar to its likely context of use. These likely application contexts are situations in which students will face ill-defined problems such as evaluating scientific findings and arguments presented in the media, determining the benefits and risks of policies (or health procedures) through research and investigation, and constructing logical and scientifically sensible explanations of everyday phenomena. It follows then that learning situations should provide students with opportunities to engage in the scientific practices of questioning, investigation, and argumentation as well as learning content in a relevant and motivating context.

CONCLUSIONS

Even in this limited review of research on PBL and IL, it is clear that the claim that PBL and IL "does not work" is not well supported, and, in fact, there is support for the alternative. But we would argue that "Does it work?" is the wrong question. The more important questions to ask are under what circumstances do these guided inquiry approaches work, what are the kinds of outcomes for which they are effective, what kinds of valued practices do they promote, and what kinds of support and scaffolding are needed for different populations and learning goals. The questions that we should be asking are complex as is the evidence that might address them. It requires one to also consider the goals of education—including not only learning content but also learning "softer skills" (Bereiter & Scardamalia, 2006) such as epistemic practices, self-directed learning, and collaboration that are not measured on achievement tests but are important for being lifelong learners and citizens in a knowledge society. In many ways, we do not yet have adequate answers to these questions concerning the conditions under which various types of scaffolded learning environments are most effective. While we are not arguing against various forms of direct and more heavily guided instruction, of the sort that Kirschner et al advocate, it is still unclear how to balance IL and PBL (which are more constructivist and experiential) with direct instructional guidance. We believe that more directed guidance needs to build on student thinking. As a field we need to develop deeper and more detailed understandings of the interrelationships between the various instructional approaches and their impact on learning outcomes in different contexts.

We wish to conclude this article with the common wisdom of Confucius on the nature of instruction and human learning: "Tell me and I will forget; show me and I may remember; involve me and I will understand." We argue that IL and PBL approaches involve the learner, with appropriate scaffolding, in the practices and conceptualizations of the discipline and in this way promote the construction of knowledge we recognize as learning.

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