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Brian R. Belland
Utah State University, brian.belland@usu.edu

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Developing My Perspectives on Scaffolding and Problem-Based Learning: A Retrospective View

Brian R. Belland (Utah State University)

Abstract

In this paper, I describe the iterative development of my perspectives on scaffolding and problem-based learning through interactions with other scholars and research. Such influences include doctoral experiences, funded projects, and exposures to research from a variety of traditions.

Keywords: retrospection, theoretical frameworks, scaffolding, problem-based learning

This article is designed to take a retrospective look at how and why my theoretical framework—the lens through which I view how students learn while solving problems with the help of technology—has evolved. This evolution has its roots partially in my own days in graduate school. But it also has undergone many evolutions due to interactions with different researchers, students, and teachers over the years.

The Graduate School Years

One important aspect of the way that I think about the role of technology in supporting student success in problem-based learning (PBL) is that technology cannot be seen as a monolithic intervention that is experienced the same way by all students. Rather, I assume that a genuine interaction happens between the characteristics and needs of students and the perceived characteristics of the technological resources.

Working with Special Education Teachers

Coming into graduate school, I had long believed that some of the strongest learning can happen when students are actively engaged in gathering and making sense of information in order to make better sense of the world than they did before. Thus, when Krista Glazewski invited me to join her team helping middle school teachers and students leverage PBL experiences to enhance learning, I was excited to get started. Each graduate assistant was assigned to work with particular teachers. I had the privilege of being assigned to work with special education teachers, physical education teachers, and a music teacher. These assignments most certainly helped me develop my perspective on what it means to engage in PBL. The special education students with whom I worked had a range of challenges, including severe, moderate, and mild cognitive disabilities, emotional disabilities, learning disabilities, and attention deficit/hyperactivity disorders. The school with which we worked had a firm philosophy that if an instructional strategy enhances learning, it should be used with all students, absent evidence that it does not work with a particular population of students. The research base on PBL among students with special needs was extremely sparse. Direct instruction has long been considered the gold standard for educating students with special needs (Englert, 1984; Gersten, 1985), and this was no different when I set out to work with these special education teachers (Heward, 2003). Indeed, the widespread adoption of scaffolding approaches for students with learning disabilities is hindered at least in part by the prominent view that direct instruction approaches are best for the population (Stone, 1998). I worked with the special education teachers to develop a unit that would seem authentic to the students and would involve all at a meaningful level. This, of course, required that much thought be put into how the essential elements of PBL could be arranged and tweaked to invite meaningful participation on the part of all students. From my perspective as a beginning PBL researcher, I knew that there was a need for an authentic problem that drove student learning. In consultation with the teachers, we chose to have students address the physical accessibility of the school's town. Each class period began with about 15 minutes

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of direct instruction, and then students began group work in which they used the central problem to drive learning. This melded the teachers' beliefs in the value of direct instruction for this population of students with the approach of PBL. Furthermore, the incorporation of lecture within the context of PBL is not new, nor is it considered a violation of the PBL approach (Fyrenius, Bergdahl, & Silén, 2005; Schmidt et al., 1996). I also researched the reactions of the students and the teachers to the unit (see Belland, Ertmer, & Simons, 2006). Of note, the students with milder disabilities acted in many ways as advanced peer tutors of the students with more severe disabilities. Both groups of students perceived this process to be especially valuable, both in terms of building compassion for and helping students with more severe disabilities and being able to engage in varied activities directed at addressing a real problem for individuals with disabilities. The teachers perceived that this helped the students to be more engaged, especially because the class was broken into shorter segments.

Thinking About How Technology Could Further Help Middle School Students Engaged in PBL

My early experiences really helped me think about how one can craft PBL experiences that serve the broadest possible group of students. But it also left me wondering whether technology could be better leveraged within PBL. Most of what I had seen was technology used to facilitate information access. This certainly helps, but at the same time, central to PBL is the ability to use information effectively—evaluating sources and synthesizing information (Macklin & Fosmire, 2004), solving problems (Jonassen, 2003), and building arguments (Belland, Glazewski, & Richardson, 2008; Jonassen, 2011b). Argumentation is a key skill desired in K–12 students (Driver, Newton, & Osborne, 2000), and research and my experience showed that middle school students in particular were in need of help developing argumentation skills (Glassner, Weinstock, & Neuman, 2005; Hogan & Maglienti, 2001; Kuhn, 1991). Thus, as my PhD studies progressed, I decided to focus on computer-based scaffolding to support the construction of evidence-based arguments. I built a conceptual framework to undergird my design (see Belland et al., 2008), and I designed a computer-based scaffold to use in my dissertation study. A friend from the computer science department, Bill White, programmed the tool using PHP and MySQL, which I called the *Connection Log*. I implemented it in conjunction with a PBL unit on the Human Genome Project in a 7th grade science class (see Belland, 2008). My idea about technologies being perceived and acted upon differently by different students played a core role in the design of the study and led to some interesting results. It was later elaborated as detailed in Belland and Drake (2013).

Working Toward Tenure

Developing My CAREER Grant Proposal

Once I began my assistant professor position at Utah State University (USU), I began thinking about how to evolve and extend my research and build toward tenure. The National Science Foundation CAREER program seemed like a great opportunity to which I could aspire. USU had a series of seed grant programs to help faculty get external grants, one of which was called the grant enhancement mentoring program. I had met David Jonassen at a few conferences and had always found him to be very willing to discuss ideas with junior colleagues. Of course his research record in the area of ill-structured problem-solving was unparalleled. I thus asked him to be my mentor, and he agreed.

Identifying and addressing gaps in the literature. I sent Dave drafts of various sections of the proposal, and we discussed them. I aimed to identify the three most critical gaps in the research on argumentation scaffolding and design my 5-year research and development program to address those gaps. In the end, the three gaps I chose to address were, "there is little examination of how different students use or are impacted by scaffolds," "transfer is rarely addressed," and "the activity supported is usually context-bound."

These discussions with Dave influenced the theoretical framework with which I view PBL, but Dave of course recognized that theoretical frameworks can and should be fluid—open to modification on the basis of new evidence. The CAREER proposal was then submitted, but one particular gap kept bothering me—transfer is rarely addressed—and I decided to work further toward developing a conceptual paper to address it. When applied to teacher scaffolding, fading had clear mechanisms (i.e., reducing the quantity and frequency of scaffolding messages) and conditions (i.e., based on dynamic assessment of student performance characteristics) (Collins, Brown, & Newman, 1989; van de Pol, Volman, & Beishuizen, 2010; Wood, Bruner, & Ross, 1976), but such mechanisms and conditions were often lacking when fading was applied in computer-based scaffolding (Belland, 2011). For example, fading in computer-based scaffolding was usually linked to self-selection (Clark, Touchman, Martinez-Garza, Ramirez-Marin, & Skjerping Drews, 2012; Metcalf, 1999; Renkl, 2002) or fixed intervals (McNeill, Lizotte, Krajcik, & Marx, 2006; Raes, Schellens, De Wever, & Vanderhoven, 2012), rather than to dynamic assessment. My conceptual framework evolved in response to reviewer comments and eventually was published (Belland, 2011). The central message was that transfer of scaffolding is not dependent on fading, but rather on the extent to which students need to maintain executive control over tasks that they are performing with the assistance of scaffolding.

Starting the CAREER project

The NSF CAREER project was funded. This was great news, but it also meant that I needed to get to work, hiring graduate students and making plans. This included working with teachers and administrators to ensure that my study plans fit their students' needs. This was to be expected, and is indeed desirable. One of the key arguments PBL proponents make is that PBL can be used to help teachers meet certain standards that they have a tough time meeting otherwise (Nariman & Chrispeels, 2015; Walton, 2014). So the goal is not necessarily to take over the entire curriculum, but rather to redesign teacher-directed units that are not working well in order to enhance learning. This is the approach that I took, and it worked well for the most part. In particular, lower-achieving students who used the scaffolding gained significantly more from pre- to posttest of argument evaluation ability as their control counterparts, and the scaffolding helped them perform at essentially the same level as higher-achieving students (Belland, Gu, Armbrust, & Cook, 2015). Furthermore, groups who used the scaffolding tended to employ more sophisticated epistemological criteria (Belland, Gu, et al., 2015; Belland, Gu, Kim, & Turner, in press).

Allowing research assistants to identify research topics of interest. One of the greatest benefits of working with graduate and undergraduate students on the project was allowing them to pursue ideas that they found interesting and to integrate such ideas into the project. Jiangyue (Grace) Gu became interested in the role of epistemic beliefs and aims on students' development of argumentation abilities. Nam Ju Kim was interested in information literacy. And Mark Weiss pursued group autonomy support and teacher professional learning for PBL. Taking the research in these different, yet complementary, directions allowed me to consider the issue of the development of argumentation abilities in a much more holistic manner. Just as PBL students do well to consider the central problem from different perspectives and angles (Jonassen, 2011a; Tan, 2003), so do educational researchers (Lather, 1992). Specifically, this multitude of perspectives helped me think about how student success in PBL is influenced by (a) student beliefs about what it means to know something influences their problem-solving processes, (b) how students evaluate and use information, (c) the extent to which student groups can function autonomously, and (d) the extent to which teachers are viewed as partners who bring extensive, valuable experience to the table.

Integrating motivational and cognitive perspectives with scaffolding. Another influence on the development of my theoretical framework was a collaboration with ChanMin Kim on a paper that we had presented at the American Educational Research Association (AERA) Annual Meeting and then submitted to *Educational Psychologist*. I had become interested in developing such a paper because I saw that often students were not motivated to use scaffolds, both in my own research and in reading that of others (Brush & Saye, 2001; Ge & Land, 2003; Greene & Land, 2000; Oliver & Hannafin, 2000). In it, we talked about the design of scaffolding to support motivation and cognition. Previously, I had very much thought of scaffolding only from a cognitive lens, which was surprising given that I had written previously of the need to consider motivation in the context of scaffolding (Belland et al., 2008). Working with ChanMin and also Clark Chinn (*Educational Psychologist* editor) and the reviewers, I began to see how scaffolding can be designed to provide integrative support for motivation and cognitive outcomes. The article was finally published (Belland, Kim, & Hannafin, 2013), and I think it provides a good example of the continuing evolution of my thinking on scaffolding. On the most fundamental level, it demonstrated my realization that it is critical to support both cognitive and motivational needs during PBL. Researchers have long perceived that addressing authentic problems is inherently motivating (Parsons & Ward, 2011; Willems & Gonzalez-DeHass, 2012). But evidence indicates that for students to be motivated, support is needed. And such support enhances cognitive learning.

It is also interesting in that earlier, when I was thinking from an entirely cognitive viewpoint about how to promote the transfer of scaffolded skills, I proposed that the key to transfer of scaffolded skills was that students needed to maintain executive control over the central task while using the scaffold. This is also a proposition that is supported by the motivation literature, in that autonomy support is a key motivational strategy (Jang, Reeve, & Deci, 2010; Ryan & Deci, 2000). But also, so many of the core recommendations of motivation researchers—that belongingness (Ryan & Deci, 2000), autonomy (Reeve, 2009), mastery goals (Bereby-Meyer & Kaplan, 2005; Linnenbrink-Garcia et al., 2012), and task value (Wigfield & Cambria, 2010) be promoted—align with much of what PBL researchers know is needed for student success: positive group work dynamics (Belland, Glazewski, & Ertmer, 2009; Lindblom-Ylänne, Pihlajamäki, & Kotkas, 2003; Lohman & Finkelstein, 2000), self-directed learning ability (Lekalakala-Mokgele, 2010; Loyens, Magda, & Rikers, 2008), and perceived authenticity of the central problem (Dabbagh & Dass, 2013; Hung, 2006). Thus, scaffolding that supports these processes plus self-efficacy and emotion regulation, in addition to cognitive variables, will likely promote positive PBL experiences.

Synthesizing Research on Scaffolding Through Meta-analysis

Another major impetus of change in my thinking on scaffolding was my NSF REESE Synthesis project, in which Andy Walker, also from USU, and I conducted traditional meta-analysis and Bayesian network meta-analysis of research on scaffolding in STEM education. This project has opened my eyes to myriad scaffolding strategies that can be used, as well as a host of different contexts in which it can be used. Anyone who has ever conducted a meta-analysis knows that it is crucial to have clearly constructed definitions, as well as examples that clearly fit the definition, and borderline cases. Having to write and revise those definitions, as well as defend them in group and advisory board meetings, made me think carefully about the essence of scaffolding. Revisiting the definitions as we reviewed more and more articles helped me to clarify and broaden my thinking about scaffolding.

PBL as Both a Research Topic and a Research Process

My journey within the PBL research community has largely followed the PBL process—an iterative process of identifying what I know and what I need to know, finding, evaluating, and synthesizing information, and building and iteratively improving arguments. The process has illustrated the crucial importance of scaffolding support—both computer-based and teacher-provided—in helping students succeed in PBL. This idea is not new (McNeill & Krajcik, 2009; Puntambekar & Kolodner, 2005; Saye & Brush, 2002; Tabak, 2004), but the particulars of how such synergy can be built is as yet not fully understood. Building a network of synergistic scaffolding support requires extensive work with teachers and iterative design of computer-based scaffolding that is informed by data and the literature. My research team and I have conducted work along these lines (e.g., Belland, Burdo, & Gu, 2015), and continue to do so, but more work is needed.

Just as students do well to consider PBL problems from multiple perspectives, so too is it crucial to consider scaffolding and PBL from multiple perspectives. To this end, I (a) pulled in the educational psychology literature to determine how scaffolding can be designed to support motivation and cognition (Belland et al., 2013), (b) conducted design-based research (Anderson & Shattuck, 2012) as well as meta-analysis (Cooper, Hedges, & Valentine, 2009) to understand the impacts of scaffolding, (c) encouraged my students to identify new directions to take our research, and (d) considered how different theoretical frameworks can be used to conduct and interpret research on problem-based learning (Fee & Belland, 2012). From the perspective of my design-based research, it is apparent that computer-based scaffolding can in large part level the playing field by substantially improving the performance of lower- and average-performing students (Belland, 2010; Belland, Glazewski, & Richardson, 2011; Belland, Gu, et al., 2015). But it largely did not help higher-achieving students. Much scaffolding work seems to either help higher-achieving students or lower-achieving students. Clearly, helping both populations is important, but more needs to be known in order to meet this goal. From the perspective of meta-analysis, scaffolding has a quite large effect on cognitive outcomes: $g = 0.46$ (Belland, Walker, Kim, & Lefler, Under review). Still, it is not fully known why scaffolding leads to larger effect sizes under some conditions. Forty years after the publication of the article that first advanced the scaffolding construct (Wood et al., 1976), there is still much to be learned about scaffolding, and it would be absurd to think that any one researcher or research group can fully answer all such questions. But any researcher can address the questions. And that is what I intend to do.

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Brian R. Belland is an associate professor of instructional technology and learning sciences at Utah State University. His research interests center on the use of computer-based scaffolding to support middle and high school students' argumentation during problem-based learning units.