Invited Talk: Making the Implicit Explicit: Issues and Approaches for Scaffolding Metacognitive Activity

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Abstract

The increasing educational focus on having learners engage in complex inquiry practices places a spotlight on scaffolding for metacognitive activity. We consider some current conceptual scaffolding approaches and examples of how those approaches are implemented in computers to explore the role of AI in metacognitive scaffolding.

Complex Practices and the Need for Metacognitive Support

Metacognitive activity is a core aspect of many multifaceted practices, but supporting such activity in educational contexts is a complex endeavor. One example of such a practice includes the substantive inquiry practices that different educational policy groups (for example, National Research Council 2000) recommend for K-12 student curricula, including those practices that involve more authentic types of scientific inquiry along with online inquiry activities that incorporate a growing number of digital libraries and other information resources. There are many characterizations of inquiry, but we can succinctly describe inquiry as a set of activities that involve: (1) asking and developing questions to investigate; (2) searching for and gathering relevant data and information; (3) reading, evaluating, and analyzing the gathered data and information; and (4) synthesizing these various information resources to develop an answer to the question being investigated (National Research Council 2000). These inquiry practices also have a "wicked nature in that inquiry involves a problem-solving process where learners must constantly make several decisions to navigate this wide range of activities in a non-linear, iterative, opportunistic manner (Quintana et al. 1999).

When we consider the metacognitive aspects of inquiry, including the typical activities that tend to fall in the metacognition category (planning, monitoring, regulation, reflection, etc.), we can see how important they are for the decision-making necessary to successfully move forward and engage in such a complex, wicked practice. Thus supporting metacognition is necessary because educators have deemed it important for students to be able to navigate inquiry practices to not only help them learn about the underlying content being supported by those practices (for example, doing a science investigation to learn chemistry content), but also to learn about the inquiry practices themselves (for example, doing a science investigation to learn about the nature of science and what is involved in science investigations).

While this particular example may involve K-12 students and science inquiry practices, the reality is that the issues around metacognition that emerge are quite similar in any context where learners are attempting to engage in a complex, multifaceted practice. Supporting the cognitive aspects of such practices is difficult enough, especially for learners who, by definition, lack significant experience and expertise in the practice. But moreover, the implicit nature of metacognitive activities makes the goal of supporting metacognition perhaps an even larger challenge. When we think about the two major learning goals described above in the science inquiry example and other learning goals put forth in many educational policies, we can see the central challenge that we want to address with metacognitive support: (1) supporting novice learners to mindfully engage in the metacognitive activity necessary to successfully participate in complex, multifaceted practices, and (2) supporting novice learners to learn good metacognitive practices what metacognitive activities are, why they are important, and how to engage in them. Supporting metacognition is vital to essentially help make these implicit activities more explicit to learners, yet we continue to see how difficult it is to provide such support.

Approaches to Computer-Based Scaffolding to Support Metacognitive Activity

The work of my research center in K-12 science education has involved developing different computer-based tools to support learners in our case, middle school students with different aspects of science inquiry. This design goal includes tackling the problem of integrating metacognitive scaffolding into these tools. Generally speaking, we follow the traditional definition of scaffolding (for example, Wood, Bruner, and Ross 1975) as the support provided by a more knowledgeable person to a learner in order to help that learner accomplish a task that he or she could not do alone. Furthermore, as the learner gains more expertise, the scaffolding should be incrementally reduced, or "faded.

While the original descriptions of scaffolding focused on
human-to-human support, we have, of course, seen a significant amount of work exploring ways in which computer-based tools can incorporate features that provide a scaffolding function. There has been much work on computer-based scaffolding to support intellectual activity, but there are still many questions and challenges. This is especially true when it comes to supporting metacognition, which remains difficult to understand, illustrate, and explicate, as illustrated by the questions being posed at this symposium. Indeed, Azevedo (2005) previously noted that there is still a significant amount of research needed on the “conceptual, theoretical, empirical, and design issues related to using computers as metacognitive tools to foster learning about conceptually rich domains.

As we continue to develop and evaluate different scaffolded software tools, we are also aiming to address some of the issues related to the conceptual design of metacognitive scaffolding. We have been reflecting on our own scaffolding work to synthesize and organize different scaffolding approaches and examples into design frameworks that describe in a more organized and rationalized manner the ways that computers can scaffold learners (for example, Quintana et al. 2004). One recent framework specifically focused on metacognitive scaffolding by looking at how different metacognitive activities (planning, monitoring and regulation, reflection) relate to the different phases of inquiry (asking questions, searching for information, evaluating and reading information, synthesizing) to outline the metacognitive challenges that learners face and some corresponding scaffolding approaches that may address those challenges (Quintana, Zhang, & Krajcik 2005).

We put forth such a scaffolding framework not as the final word on metacognitive scaffolding, but rather as an extensible artifact to foster additional work and to provoke more discussion on the various ways that computers can scaffold metacognition. This framework also helps us look at different conceptual metacognitive scaffolding approaches and examples of how those approaches have been implemented in software to help us: consider the role of AI-based techniques in scaffolding, see where AI can scaffold learners, and determine where AI approaches may not be useful, or even feasible, for scaffolding metacognition.

We will see that many of the scaffolding techniques in our current framework do not use AI at all, instead employing approaches such as textual reflective prompts, process visualizations, planning tools, and user-triggered help features. We can use these examples as a counterpoint to think about how and when AI can (or cannot) scaffold metacognitive activity and how we might combine AI and non-AI techniques into a larger scaffolding foundation. Furthermore, we can also begin to articulate additional issues, questions, and challenges for metacognitive scaffolding that especially arise in today’s rapidly-evolving technology landscape: How might metacognitive scaffolding features differ on “big computers (for example, desktop and laptop computers) versus “small computers (for example, smartphones, tablets, other mobile devices)? How do we integrate the scaffolding potential of the visual human-computer interface with the “under-the-hood functionality that may include intelligent features? How do we (or can we) adapt scaffolding to different learner audiences and how can we successfully fade scaffolding as learners gain experience and expertise? And finally, do we yet know enough about metacognition to help us develop the kinds of task models that can help us develop more intelligent technologies for scaffolding metacognition?

References


