The Connection Log: Scaffolding the Development of Middle School Students’ Evidence-Based Arguments

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Abstract
Students engaged in Problem-based learning (PBL) units solve ill-structured problems in small groups, and then present arguments in support of their solution. However, middle school students often struggle developing evidence-based arguments (Krajcik et al., 1998). Using a mixed method design, we investigated (1) the impact of the Connection Log—a computer-based argumentation scaffold system—on middle school students’ construction of evidence-based arguments during a PBL unit, and (2) scaffold use among members of two small groups purposefully chosen for case studies. Data sources included a test of argumentation, debate rating scores, videotaped class sessions, and retrospective interviews. Findings included a significant impact on individual argumentation skill, and use of the scaffolds by the small groups to communicate and keep organized.

Introduction
Recently, science educators have called for the use of inquiry-based instructional frameworks such as problem-based learning (PBL) to help secondary students to learn the process of science (i.e., the inquiry process), and move beyond instruction focused on declarative knowledge (e.g., Keys & Bryan, 2001; Sandoval & Reiser, 2004). In PBL, students center their learning on ill-structured problems, or problems for which (1) the initial statement does not indicate how to represent the problem, and (2) there are multiple paths to a solution and multiple solutions to the problem (Hmelo-Silver, 2004; Jonassen, 2003).

Within ill-structured problems, developing evidence-based arguments (EBAs) is essential to producing a viable solution (Cho & Jonassen, 2002). EBAs consist of discussions that provide support for claims with evidence and premises (Perelman & Olbrechts-Tyteca, 1958). However, secondary students often struggle creating EBAs (Krajcik et al., 1998; Sandoval & Reiser, 2004). Middle school students’ inability to construct EBAs during PBL could be attributed to three challenges: (1) adequately representing the central problem of the unit (Ge & Land, 2004; Liu & Bera, 2005), (2) determining the most relevant evidence they must gather and gathering it (Pedersen & Liu, 2002-2003), and (3) synthesizing gathered information to construct a sound argument (Cho & Jonassen).

Possible Solutions
While some authors advocate direct instruction to help K-12 students improve argumentation skills (Knudson, 1991; Voss & Means, 1991), such interventions are not always successful (Knudson; Marttunen & Laurin, 2001). Also, while direct instruction may help secondary students engaged in PBL units learn the components of EBAs, such students may continue to struggle representing the problem, determining relevant information to gather and gathering it, and synthesizing the gathered information to construct a strong argument.

Scaffolding is support (from a teacher or computer tool) provided to students participating in a task they cannot complete without assistance (Hannafin, Land, & Oliver, 1999; Wood, Bruner, & Ross, 1978). Computer-based argumentation scaffolding has helped college (Cho & Jonassen, 2002) and middle school students (Bell, 1997) produce coherent arguments. However, many available computer-based science-inquiry scaffolds are linked to specific PBL problems (Quintana et al., 2004), and transfer to other problems or domains has not been shown.

We designed and developed a computer-based scaffolding system, the Connection Log, to support middle school students’ development of EBAs during a variety of PBL units. The purpose of this paper is to describe the Connection Log and to address how and why middle school science students use computer-based argumentation
scaffolding to construct an argument while participating in a PBL unit, and the Connection Log’s impact on (a) individual student argumentation skills and (b) group argument quality.

Method

Design and Development of the Connection Log

The first author designed the Connection Log based on guidelines that emerged from a review of the literature and detailed observations of middle school students engaging in PBL: (1) embed scaffolds within a system, (2) make students articulate their thoughts, (3) constrain the problem space, (4) consider motivation, (5) make scaffolds explicit for students with less prior knowledge, and (6) focus on the development of conceptual, procedural, and strategic computer-based scaffolds (Belland, Glazewski, & Richardson, in press). The third author reviewed the instructional analysis once and the storyboard twice. After revising the storyboard, the first author reviewed scaffold readability with a seventh-grade science teacher and several seventh-grade students. We simplified the language where possible, and implemented rollover definitions where necessary.

Resources Used

We used Macromedia Fireworks version 8 to storyboard. The html shell was created using Macromedia Dreamweaver version 8. The php code was written using vi (text editor for UNIX). Database architecture was modeled using Toad™ Data Modeler. A Sun server running php 5.1.4 and mysql 5.0.22 hosts the Connection Log.

Evaluation

Setting and Participants

This setting was a laptop initiative middle school in a small, rural Midwestern community. The school had 38 teachers and 543 students, 44% of whom received free or reduced lunches. The sample included eighty-six seventh-grade science students in four class sections. The teacher had four years experience facilitating PBL units.

Data were gathered during a 2-week PBL unit on the Human Genome Project (HGP), which followed a teacher-led instructional unit on genetics and its role in human development. Each student team chose a unique stakeholder group such as doctors or religious leaders. Students needed to assume a position on the HGP based on their stakeholder’s perspective, outline a plan for promoting their position, and argue their position during a debate at the end of the unit in fictitious competition for a grant to further their position.

Design

We used a mixed methods approach to address our research questions.

Qualitative method. We presented an in-depth description of how the members of two small groups worked together and used the scaffolds during the unit.

We (1) videotaped each group during the unit, and transcribed verbatim all dialogue, (2) retrieved each group member’s response to prompts, (3) observed students from all class sections during the unit, and (4) conducted prompted, retrospective interviews of approximately 30 minutes each with each group. In each interview a unique, approximately 20-minute video containing scenes from the videotaped class sessions prompted participants’ recollection of how they used the Connection Log and why.

We (1) coded the video and interview transcripts, (2) triangulated coding with observation and database information, (3) identified common themes, and (4) interpreted themes from the symbolic interactionism framework, according to which people interact with things based on the meaning they assign to the latter (Blumer, 1969).

Quantitative method. We used a two-factor nested experiment with factor B (classroom) nested in factor A (scaffold or no scaffold) (Kerlinger & Lee, 2000). The teacher identified two classes as high-achieving and two as low-achieving. The low-achieving class means were significantly lower than those of the high-achieving classes, $F(1, 81) = 6.93$, $p < .05$, on a pretest of argumentation ability. Pretest scores did not differ significantly between the low-achieving, $F(1, 81) = .38$, $p = .54$, or the high-achieving, $F(1, 81) = .62$, $p = .43$, classes. We assigned one high-achieving and one low-achieving science class to each condition: scaffold and no scaffold.

An argumentation measure was adapted with permission from the test used by Glassner et al. (2005). Students read four scenarios in which a claim was made about a particular topic and two supporting statements were
advanced. Students needed to indicate how well each statement supported the original claim. The pretest (Cronbach’s alpha=.71) was similar to the posttest (Cronbach’s alpha=.77).

To address the impact of the Connection Log on individual argumentation skill, we used nested ANOVA. If nested effects were significant and ordinal, we calculated simple effects (Keppel, 1982).

We videotaped all groups during the debate. The video was transcribed, and two raters blind to treatment condition assigned numerical scores for claim, evidence, and connection of claim to evidence quality for each team in all four periods. After raters came to consensus, agreement, measured by Cohen’s Kappa, was 0.99.

To address the impact of the Connection Log on group argumentation quality, we used nested MANOVA. If effects were significant, we ran follow-up ANOVAs. If nested effects were significant and ordinal, we calculated simple effects (Keppel, 1982).

Results

Connection Log Description

General Description

The scaffolds are organized as six stages:
1. Define problem, in which students define the problem in their own words
2. Determine needed information, in which students decide on evidence and information about the problem they need to find, and strategies for finding it
3. Find needed information, in which students find and record the information they need to know
4. Organize information, in which students organize the information they found to make it more useful when developing their claims and building their argument
5. Develop claim, in which students actually develop their claims
6. Link evidence to claim, in which students link evidence to their claims and build an argument

Each stage is divided into 2-4 steps. See Figure 1 for a screenshot of step 1 of stage 1. Most steps have text boxes in which students type responses. Upon logout, all work is saved. Students start where they left off when logging back in.

Figure 1. The Connection Log.
Unique features. The Connection Log was developed for use with any PBL unit and guides students to articulate their thoughts. Because of group registration, students read what their group mates articulate at each stage. At each stage in the argument construction process (e.g., organize evidence, develop claim) students (1) articulate their own thoughts individually, and (2) discuss all group members’ articulated thoughts to form a group consensus.

How Do Students Use Computer-based Argumentation Scaffolding?

Group 1

Robert, Erin, and Alejandra (note: all names were changed) faced different challenges during the unit. Robert was a leader who found the unit difficult due to his lack of prior knowledge about the unit content. He was also confused about the debate structure.

Erin was often unsure of herself. On many occasions when either Alejandra or we asked Erin a question about the group’s strategy or how the HGP could help their stakeholder, she replied, “I don’t know, ask Robert.” She appeared to accept Robert’s lead, but complained that sometimes it seemed like “Robert doesn’t care.” She also was confused about the overall task.

Alejandra had limited English proficiency. She struggled expressing herself and understanding what her teammates said, but was able to stay aware of her group mates’ thoughts by reading what they wrote in the Connection Log. In this quote she reflected on her silence: “I was listening. I always listen. I was listening to what she was saying. Because I was trying to help, but they always talk, and I was trying to listen, but Erin talks too fast.”
The group used the Connection Log to (1) get and stay organized, (2) aid communication, and (3) think of ideas. The Connection Log appeared to help the group to counter (1) confusion about the debate structure and required presentation parts, and (2) communication problems by allowing them to read what each other wrote.

**Group 2**

Daniel, Megan, and Claudia faced different challenges during the unit. Daniel was a soft-spoken leader who tended to take over tasks when required to explain them too much. He was challenged by the ill-structured nature of the unit. Though he understood them from the beginning, he found it challenging to apply the Connection Log’s prompts to his project early in the unit. However, as we explained them more, Daniel found the prompts easier to apply.

Claudia was an English language learner who joined the group with three days left in the unit, and was assigned the task of finding pictures and information to complete the group’s poster. She found the unit more difficult than previous inquiry units due to difficulty finding information. Because of her late addition, she did not use the Connection Log extensively.

Megan was a quiet student who also found the unit difficult because of its ill-structured nature. She often asked Daniel how to accomplish tasks. She noted difficulty getting started with the Connection Log, but once she got going, “it was pretty easy.”

The group used the Connection Log to (1) get and stay organized, (2) serve as a reference, and (3) ensure inclusion of all required parts of the presentation. The Connection Log appeared to help the group counter their challenges by (1) structuring the unit to aid organization and strategy, (2) storing ideas for later reference, (3) indicating required parts of the presentation.

**What is the Impact on Individual Students’ Argumentation Skills?**

The Connection Log had a significant main effect on individual argumentation ability \( F(1, 82)=2.99, \, p=.09, \, ES=0.35 \) and a significant simple effect on the individual argumentation ability of low-achieving students \( F(1, 82)=6.07, \, p=.01, \, ES=0.61 \). In other words, the Connection Log significantly affected the individual argumentation ability of all students, but had an effect of greater magnitude on the individual argumentation ability of low-achieving students.

**What is the Impact on Group Argumentation Quality?**

The Connection Log did not have a significant main effect \( \Lambda=0.88, \, F(3, 25)=1.16, \, p=.34 \), but a significant nested effect \( \Lambda=0.66, \, F(6, 50)=1.95, \, p=.09 \) on claim, evidence, and connection of claim to evidence quality. Follow-up ANOVAs indicated significant nested effects of the Connection Log on claim \( F(2, 27)=4.77, \, p=.02 \) and connection \( F(2, 27)=4.52, \, p=.02 \) scores, but simple effects were not significant. In other words, when considering all scores and student types, not all means were determined to be the same. When considering only claim or connection scores, scaffolding’s effect appeared to differ according to student type, but further tests did not provide evidence of a significant difference.

**Discussion**

How do Small Groups of Middle School Science Students Use Computer-based Argumentation Scaffolding to Construct an Argument while Participating in a Problem-based Learning Unit?

When considered in context of what is currently known about how secondary students use scaffolding, the results related to how students used the Connection Log are interesting in that they add to the research base on how middle school students use hard scaffolds.

The capacity of hard scaffolds to facilitate organization. As Daniel noted, the Connection Log “helped us put it [the presentation] together so it didn’t look confused and sloppy.” Most articles in which the coherence of arguments was examined indicate that college (Cho & Jonassen, 2003; Ge & Land, 2003) and secondary (Bell, 1997; Kyza & Edelson, 2005) students who used evidence-based argumentation scaffolds produced more coherent arguments than students in control conditions (who did not use scaffolds). However, very few seemed to indicate why. Some authors noted that students using scaffolds more evidential support for claims (Cho & Jonassen) than
students who did not use scaffolds, but it is left to the reader to imagine what specifically about using the scaffolds led to the more coherent argumentation.

A closer look at what leads to argumentation coherence may reveal a possible impetus for greater argument coherence. Coherence of argumentation depends on three things: a clear claim, adequate supporting evidence, and an established link between the evidence and the claim (Perelman & Olbrechts-Tyteca, 1958). Essential to successfully linking evidence and claim and delivering an argument is organization (van Eemeren et al., 2002). In past studies in which secondary students who used scaffolds created more coherent arguments (Bell, 1997; Kyza & Edelson, 2005), students in the experimental condition may have been more organized than students in the control conditions, and that the increased organization contributed to more coherent argumentation. However, given that the authors did not present data to that effect, one cannot know.

The finding that the Connection Log helped Groups 1 and 2 stay more organized makes sense when one considers the poor organization of many groups in the control condition, many of whom jumped from one topic to another during the debate, and who did not appear to coordinate their efforts well during the unit. In my (first author) observations of all classes during the unit, I noticed that some groups in the control condition experienced difficulty staying organized. Often such groups researched a topic, researched the topic again later during the unit, and then researched it yet again. However, they were not looking for new or deeper information about the same topic, they were looking for the same type of information. For example, a group with the stakeholder perspective of adopted children in one of the control classes continually researched how many adopted children there were in Indiana and in the U.S. They asked me to help them find information on Day 3, and I provided them two links that they could use as well as strategies for finding further information. They continued to search for information about the number of adopted children in the US and in Indiana for much of the rest of the unit, usually finding the same sites. Part of the reason that they were stuck in a cycle of continually searching for the information may have been a lack of organization. They clearly did not keep track of search histories or strategies.

That the groups that used the Connection Log appeared to be more organized than students who did not use the Connection Log is in line with the findings of Simons and Klein (2007), who found that students who were required to use scaffolds were more organized than those who were in the scaffolding optional and no scaffolding conditions. Greater organization as supported by scaffolds benefits not only argumentation, but also ill-structured problem-solving success (Jonassen, 2003).

The capacity of hard scaffolds to promote inclusion of all required project parts. Daniel noted that the Connection Log helped his group ensure that they included all required parts of the presentation. This is consistent with the findings in the literature that students who are exposed to evidence-based argumentation scaffolds in the form of question prompts or video modeling determined more relevant information to gather than students in control groups (Pedersen & Liu, 2002-2003).

Many articles we reviewed that did not employ control groups also indicated that scaffolds promote the inclusion of all required project parts (e.g., Kyza & Edelson, 2005). Daniel’s group’s efforts to find evidence to support their claims mirrored that of groups who were prompted by empty evidence boxes in Progress Portfolio to include more evidential support for their hypotheses (Kyza & Edelson). This could be because the Connection Log fulfilled the group’s conceptual scaffolding needs by guiding its members on what to consider (Hannafin et al., 1999). However, few authors articulate what about the scaffolds promotes the inclusion of all required project parts. Especially when scaffolding was not designed expressly for use with a particular unit, what about the scaffolding makes students add more information in order to meet project requirements? In Daniel’s group’s case, it appeared to be the act of looking back at what his group had entered into the scaffolds alongside the prompts that guided his group as to what to find. Members of Group 2 thus appeared to be scaffolded not only by what we had written a priori in the scaffolds, but what they wrote in the text boxes of the scaffolds as they went through the unit.

The Connection Log as reference and communication aid. A very interesting finding was that the Connection Log helped the members of Group 1 to communicate. Our literature review indicated that students might benefit from being required to input their responses to question prompts into a database that could be accessed later (Blumenfeld et al., 1996; Kyza & Edelson, 2005). We thought that in the process of articulating their thoughts, students would think about what they were thinking, and that by writing what they thought, the exact rendering of their thought would be available for their group mates to read and analyze. This effect appeared to be manifest in Erin’s experience with the Connection Log, as she noted benefiting from having to create a textual representation of what was in her head.

However, the nature of the communication aid that the Connection Log appeared to provide to the group—facilitation of communication between the native-English-speaking members of the group and the ENL member and
continuity of the group’s functioning when a group member was temporarily absent—was of a nature that we had not envisioned or encountered during our literature review. First, the question of what scaffolding needs ENL students have and how computer-based scaffolds can be designed to fulfill those needs has to our knowledge not been addressed in the scaffolding literature. That Alejandra felt that she could stay aware of what her group mates were thinking and doing by reading what they wrote in response to the Connection Log’s prompts is interesting in that it suggests new areas of scaffolding that should be investigated. Though Alejandra is only one ENL student, the fact that she felt involved in the group as a result of reading what her group mates wrote rather than what they said suggests a possible new line of research into scaffolding in K-12 settings: what features of computer-based scaffolds best support ENL student’s efforts during PBL units.

Second, Erin and Alejandra contended that the Connection Log helped the group function when Robert went to another part of the room. We found no literature in which cases of small groups working in PBL units are described in which one group member goes off to be alone, and the other group members describe what helped them continue during his/her absence. However, communication problems normally ensue when one of two people who are talking leaves in mid-conversation. That the Connection Log countered some of those difficulties by allowing Erin and Alejandra to read what Robert had written is interesting and merits further investigation.

Group 1’s members also noted that they appreciated being able to compare each other’s ideas. As Robert noted, many times group members would write one thing and say another. When this happened, the group members could hold a discussion about what they really meant in order to come to consensus. We found no articles in which the capacity of hard scaffolds to promote the process of comparing ideas was explored. However, Robert’s comment makes sense because often during the unit Erin found herself saying one thing and writing yet another. As she noted, “everything always sounds better in my head.” By being forced to commit her idea to writing, Erin also made her idea available to her group mates. Alejandra also committed ideas to group discussion through the use of the Connection Log. While we found that Robert was the group leader, not all group ideas originated with him. This finding is consistent with findings in the literature that computer-based scaffolds can provoke the discussion and explanation of ideas among group members, and that this interaction in turn can lead to better ideas.

Another interesting finding is that the members of Group 2 used what they typed into the Connection Log as a reference. Though members of Group 1 did not specify that they used what they wrote in the Connection Log as a reference, they did note using what they wrote for the presentation, which indicates that they did consult their notes when coming up with their presentation. This finding is consistent with the finding that students in control conditions did not consult notes when coming up with a solution, while students using Progress Portfolio (in which they could record thoughts) did (Kyza & Edelson, 2005). However, often students engaged in inquiry units did not consult their paper-based notes when determining a solution (Blumenfeld et al., 1996) or evaluating why a solution was not ideal (Puntambekar & Kolodner, 2005). That the members of Groups 1 and 2 referred to their notes when determining a solution is promising and warrants further research. If the Connection Log can lead students to consider their research when arriving at a solution, it could help students engaged in PBL be more efficient and successful. Few would argue that research done during a PBL unit should be forgotten after it is performed, or that students should research the same topic multiple times to find the same information.

What is the Impact of the Connection Log on Individual Argumentation Skills?

Main Effect of the Connection Log on Argumentation Scores

The main effect of the Connection Log on the individual argumentation scores is interesting for several reasons. First, articles examining the impact of hard argumentation scaffolds to tend to not employ the use of transfer tests of content knowledge or skills as response measures. To our knowledge none that involve middle school students use such tests. So our finding of a significant effect of the Connection Log on individual argumentation adds to the literature base on argumentation scaffolding for that reason.

Second, the overall effect size of 0.35 indicated that the magnitude of the effect of the Connection Log on individual argumentation skill was medium-small (Cohen, 1969). It is important to note that the effect was achieved through use of the scaffolds during a PBL unit during an eight-day span. Students only started using the scaffolds, and then only for about ten minutes, on the third day of the unit. Though an effect size of 0.35 is not enormous, it does appear to suggest that the Connection Log can positively impact student achievement in a substantial way.

Direct instruction has not produced consistent results in raising middle school and other students’ argumentation skills (Knudson, 1991; Martunnen & Laurinen, 2001). Thus, the Connection Log’s significant effect on individual argumentation skills is important in that it suggests that scaffolds such as the Connection Log may fill an important gap in helping middle school students raise their argumentation skills. One characteristic of successful
middle school “graduates” is that they are intellectually reflective people who can “analyze problems and issues, examine the component parts, and reintegrate them into either a solution or into a new way of stating the problem or issue” (Carnegie Council on Adolescent Development, 1989, p. 15). Another characteristic is that they “have learned to learn, a critically important capacity because of the rapidly changing nature of occupations and jobs” (CCAD, p. 15). In short they should be able to solve problems and build effective arguments.

*Nested Effect of the Connection Log on Argumentation Scores*

The finding of a simple main effect of greater magnitude than the main effect of the Connection Log on the individual argumentation skills of lower-achieving students may indicate that certain aspects of the Connection Log supported greater improvement in lower-achieving students’ ability to recognize the extent to which a statement supports a claim. It is not clear why this may be the case as there is little literature that examines the differential impact of evidence-based argumentation scaffolding on different types of students. However, it may be that differences in the magnitude of the effect of the Connection Log resulted from students in the lower-achieving sections using the Connection Log in a different way than students in the higher-achieving sections. Insight into the different ways higher-achieving and lower-achieving students used the connection log may be gained from looking at the ways Group 1 and Group 2 used the Connection Log. Like Daniel’s group, Robert, Alejandra, and Erin used the Connection Log to get and stay organized. But they also used the Connection Log to aid communication and to compare ideas, while Daniel’s group did not.

The interesting finding to discuss in terms of the impact of the Connection Log on individual argumentation skill is its use to compare ideas. The process of comparing ideas, especially when the ideas are about evidence and claims could potentially raise one’s skill in evaluating the evidential support for a claim because it is essentially practice performing the task. That is, Robert, Alejandra, and Erin were comparing ideas and trying to come to consensus, they had to explain to each other why they thought that a particular piece of evidence supported or not their claim, or if their claim was valid. Daniel’s group did not claim to do this and did not appear to do this as much from the video evidence. Practice performing a task can vastly improve one’s ability to perform it. Observations indicated that many groups in the higher-achieving section of the experimental condition did not appear to engage in as many types of conversations of this type, but that other groups in the lower-achieving section of the experimental group did.

The effect size for the treatment among lower-achieving students of .61 was medium (Cohen, 1969). Given the initial difficulties that the students experienced using it and the relatively short treatment length, the impact of the Connection Log on individual argumentation skill appears to be substantial, and should be investigated further.
What is the Impact of the Scaffolding on Group Argumentation Quality?

The finding of no significant effect of Connection Log on claim, evidence, or connection scores was disappointing, and may be due to low power to detect significant differences. The power to detect significant effect of the Connection Log was 0.19, and the power to detect significant nested effect of the Connection Log was 0.35. Such low power makes it less likely that a researcher will detect significant differences.

The finding could also be due to a ceiling effect. Sixteen out of 30 groups attained the maximum score of six on claim, nine out of 30 groups attained the maximum score of six on evidence, and 13 out of 30 groups attained the maximum score of six on connection. This large number of maximum scores leaves one to wonder whether some of those groups would have scored higher than six if the scale had been wider.

There is a relative lack of studies in which transfer of scaffolded skills is measured. The lack of a significant effect of the Connection Log on group argumentation quality is consistent with the findings of Cho and Jonassen (2002), who did not find a significant transfer of argumentation scaffolds on problem-solving tasks. The finding is also partially consistent with a study in which scaffolds’ transfer to a problem-solving task, as compared to didactic and help conditions, was inconsistent (Pedersen & Liu, 2002-2003).

Limitations and Suggestions for Future Studies

In this section we discuss suggestions for future research using (1) the Connection Log with a similar unit, (2) the Connection Log with a different unit, and (3) other systems developed using the guidelines for the development of computer-based scaffolds to support evidence-based argumentation.

Using the Connection Log with a similar unit. Future researchers should investigate how other small groups use the Connection Log and other scaffolding systems like the Connection Log in similar and different units. Also important is determining if students from similar and different student populations use the Connection Log in a similar manner as Groups 1 and 2 on a similar unit. We specifically chose to focus on how two small groups used the Connection Log so that we could gain in-depth information. However, such a strategy limits the potential generalizability of findings (Stake, 1978). It is likely that members of other groups would use the Connection Log in different ways. Would other groups use the Connection Log to compare ideas and/or to aid communication? Would they use it to get and stay organized, or to ensure inclusion of all required project parts?

Future researchers should also use a wider rubric to assess students’ debate performances. The potential ceiling effect may have contributed to the lack of significant results in this study. A rubric that allows for a greater number of possible scores may allow more substantial differences in scores to emerge between groups.

Using the Connection Log with a different unit. We designed the Connection Log so that it could be used in a variety of PBL units. As such, it would be important to determine if similar impacts on individual argumentation skill and group argumentation quality can be ascertained when the Connection Log is used in conjunction with units of differing content, length, and depth. For example, if the unit topic were global warming, and students needed to write a letter to Congress expressing their opinion about global warming and what should be done about it, would students use the Connection Log in a similar manner to Group 1, Group 2, or neither? Would lower-achieving students tend to use it in a similar manner to Group 1, and higher-achieving students in a similar manner to Group 2? Or would they use the Connection Log in a different manner?

Using the Connection Log with a different unit and with a similar unit, it would be interesting to determine the extent to which the system helps ENL students with limited English proficiency be involved in their group. It is possible that Alejandra was an isolated case and that other students with similar difficulties speaking and understanding spoken English would not benefit from reading what their group mates wrote in the Connection Log.

Used with a unit of different topic or length, the Connection Log may have an impact on group argumentation quality. This can only be learned with further research.

Using other systems. An interesting study would examine how students use other scaffolds developed using our guidelines for the development of computer-based scaffolds to support the creation of evidence-based argumentation. Would features inspired by the guidelines (e.g., networked connectivity), and exhibited by other scaffolding systems, be helpful to middle school students? Would such a scaffolding system show positive impact on individual argumentation skill or on group argumentation quality?

Last, future research should examine when and how the Connection Log or other systems like it could be faded, as the literature base currently does not describe well the fading of hard scaffolds (Pea, 2004; Puntambekar & Hübscher, 2005). The guidelines for the development of argumentation scaffolds that recommended that all scaffolds be part of a system and that students articulate their thoughts caused me (first author) to design the Connection Log in such a way that fading it would have been difficult. Each student needed to type their answers to
prompts in order for group mates to be able to read each other’s input. One of the only existing models for the fading of hard scaffolds involves students individually deciding when they do not need the former any more (Puntambekar & Hübscher). But if a group using the Connection Log were made up of Students A, B, and C, and Student A decided she did not need the scaffolds any more, but Students B and C deemed that they did, that would be a problem. We do not know how the Connection Log could be individually faded. However, that does not mean that it cannot be done.

Conclusion

Students will face unique challenges in the 21st century, and to help them prepare, schools need to incorporate inquiry-based instructional activities such as PBL so that students engage in authentic inquiry in school (Brush & Saye, 2001; Gallagher, 1997; Keys & Bryan, 2001; Sandoval & Reiser, 2004). Creating evidence-based arguments is central to student success during a problem-based learning unit (Jonassen, 2003). Doing so is particularly difficult for middle school students due to challenges (a) adequately representing the problem that is the focus of the unit (Ge & Land, 2004; Liu & Bera, 2005), (b) determining the most relevant evidence that they must gather and the process of gathering it (Pedersen & Liu, 2002-2003), and (c) synthesizing the information that they gathered to construct a sound argument (Cho & Jonassen, 2002).

Scaffolding has been advocated as one way to help college (Cho & Jonassen, 2002) and secondary (Bell, 1997) students build evidence-based arguments while participating in PBL unit. We designed and developed the Connection Log to support the creation of evidence-based arguments among middle school students engaged in a variety of PBL units, and implemented it in two out of four class sections participating in a PBL unit on the HGP. We detected no significant differences on claim, evidence, or the connection of claim to evidence ratings of debate performances. However, students used the Connection Log in different ways, and we found a significant main effect of the Connection Log on individual student argumentation ability, as well as a significant simple main effect of the Connection Log on the individual argumentation ability of lower-achieving students. Results of this study show the potential of the Connection Log to help middle school students overcome the challenges of creating evidence-based arguments.

References


