The Knowledge Connections Analyzer

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Abstract: We describe the development of an SQL-based formative assessment system, the Knowledge Connections Analzyer (KCA), which is designed to provide evidence on four general questions that students may have about their work in an asynchronous online discussion environment: (1) Are we collaborating? (2) Are we putting our knowledge together? (3) How do ideas develop over time? (4) What is happening to my stuff? These questions are inspired by Scardamalia's knowledge-building principles. The KCA first converts a Knowledge Forum® tuplestore database to SQL format, and then executes queries relevant to these four questions. It Students and their teacher can employ it to self-assess their knowledge building. This paper elaborates upon a conceptual framework underlying the system design, describes the KCA, and reports the results of several rounds of usability testing involving teachers and students.

Introduction

In the last decade there has been much interest in education in the use of discourse—writing, reading, and other actions—in Web-based environments. The best known environments inlcude learning management systems like Moodle® and WebCT®, and more specialized inquiry environments such as Knowledge Forum®. Knowledge building is one of the most developed educationals models that involves computer-supported discourse; one of its most important features is that students' efforts are directed at advancing the collective knowledge in a community (Scardamalia, 2002). Students are not just trying to understand things for themselves but aim to add something new to what is known in the community. In this context, Knowledge Forum® is used to support "participatory practices" (Hickey et al., 2010) where participants share and collaboratively improve and synthesize ideas.

Recently, interest in the large-scale implementation of approaches like knowledge building, which aim to help students to develop 21st century skills such as collaboration, ability to deal with novel situations, and self-regulated learning, has been mounting. However, one important challenge is that assessment tools need to become widely available that can be used by teachers and students to self-assess their knowledge building efforts. For example, to what extent can we say that there are collaborative dynamics, synthesis and rise-above, and improvement over time, and what are individual students' roles and accomplishments? Such questions access both individual and collective aspects of knowledge building, and process as well as accomplishments. Ability to have data in hand to reflect on such questions is important for the development of knowledge-building discourse.

The literature on asynchronous online discussions overwhelmingly demonstrates that such discussions have disappointing rates of participation, depth of inquiry, and knowledge advancement (Pifarre & Cobos, 2010); they often remain at the level of "conversations" in which students share opinions and ideas, and engage in superficial arguments, without advancing the collective knowledge of the community. Although we have made progress in conceptualizing the nature of discourse required (Scardamalia & Bereiter, 2006; van Aalst, 2006), better assessment tools are needed. Currently assessments of online discourse consist of content analyses that examine specific features of the discourse (e.g., how knowledge is constructed, the epistemic levels of students' questions and ideas, and how ideas are diffused), but these types of analysis are too labor-intensive to inform students' efforts while they are in progress. To scale up approaches like knowledge building, it is essential to develop assessment technologies that can provide students and teachers with useful information about their discourse and what it is accomplishing—and that such tools can be used by teachers and students' themselves. For the knowledge-building community the problem is urgent because the Analytic Toolkit for Knowledge Forum is becoming technically outdated, and does not provide all of the analyses that are now needed.

This paper provides a brief report on the development a formative assessment tool, the *Knowledge Connections Analzyer (KCA)*, which focuses on the use of Knowledge Forum® server data to provide *students and teachers* with information about their knowledge building dynamics for self-assessment and reflection. The KCA provides analysis on four general questions students may have about their online discourse. It is hoped that our conceptual framework behind these designs contributes to the presentation of server log data as

evidence to support the efficacy of self-assessment, reflection, and work improvement in an online environment. Meanwhile, we hope the development of the system represents an on-going effort to implement and refine our formative assessment framework for web-based discussions.

Formative Assessment

In various forms, assessment drives educational practice (Biggs, 1996). Interest in formative assessment received a boost after the major review by (Black & Wiliam, 1998), which showed substantial positive impacts of formative assessment on learning. However, these practices seem to focus on such things as providing feedback on student work (e.g., tests and projects) and in-class questioning.

Knowledge Forum® is recoganized as a typical form of computer-supported collaborative learning (CSCL) environments (Salovaara & Järvelä, 2003; Scardamalia & Bereiter, 1996). An extensive review of measures and assessment in CSCL research shows that "after collaboration" measurement has played a dominating role, while there is an insufficient collection of tools and measures for examining processes involved in CSCL (Gress et al., 2010). To avoid such an "afterwards" style and to capture the knowledge building dynamics, we adopt the perspective of *formative assessment* (Scriven, 1967) to frame our work: *the tool should provide assessment for students and teachers to reflect on knowledge building, when it is still in progress, and that is used to enhance knowledge building*. We developed a web-based system for teacher-driven and student-driven formative assessment. Knowledge-building theory emphasizes that assessment is an integral component "embedded" in knowledge building and "transforms" it: it constitutes collaborative *inquiry* into the nature of the community's work and its progress, and leads to new actions designed to enhance both (Scardamalia, 2002). Thus, formative assessment is not epistemologically distinct from knowledge building, except that the domain of the inquiry is not subject matter (e.g., science concepts) but the process of knowledge building.

Embedded Knowledge Building Principles

Scardamalia (2002) proposed a 12-principle system to describe the socio-cognitive and technological dynamics of knowledge building (the explanations of the principles are omitted due to the length limit). In practice, however, many teachers find this system complicated, in part because the principles overlap and lack the precision necessary to distinguish knowledge building from other approaches. For example, many educational approaches involve inquiry into authentic problems, idea diversity, metacognition, the constructive use of authoritative sources, and the democratization of knowledge (Kolodner et al., 2003; Polman, 2000). The KCA is thus designed around four general questions that students may have about their online work:

(1). Are we collaborating?
(2). Are we putting our knowledge together?
(3). How do ideas develop over time?
(4). What is happening to my stuff?

Implementing Knowledge Forum® environment has shown impact on student, teacher and school development at various levels of educational context (Chan, 2011). Although we cannot take for granted that students' development of conventional proficiencies has been well addressed by the implementation of Knowledge Forum®, we would like focus on assessing the aforementioned four aspects in this paper. On the one hand, the assessment is to help students reflect on their knowledge building work that is still in progress, rather than what proficiencies they have acquired. On the other hand, reflection on the knowledge building principles is the underlying rationale for the four questions. Table 1 lists the key purpose, knowledge building principles, and the major analyses that have been implemented in the KCA system.

Table 1: Embedded Knowledge Building Principles in Four Questions.

Questions	Key Purpose	Knowledge Building Principles	Major Analyzing Indicators
Are we collaborating?	A community-oriented question that asks whether collaboration is a well-developed practice in the community	*Democratizing knowledge, Idea Diversity, Improvable Ideas, Epistemic Agency,*	To what extent students *have an audience* for their work in the form of read, build-on, etc. to their notes
Are we putting our knowledge together?	To explore the extent to which synthesis and rise-above are occurring from collective aspect	*Rise Above Community Knowledge, Collective Responsibility, Idea Diversity*	The percentage of build-on links and the percentage of refer-to links
How do ideas	To explore the extent of	*Improvable Ideas,*	The percentage of notes that

| develop over time? | community engagement, and the emergent of new ideas from collective aspect | *Epistemic Agency* | have received a certain level of interaction, keywords introduced, scaffolds used |
| What is happening to my stuff? | To reflect on one's own note-writing efforts from individual aspect | *Embedded, Concurrent and Transformative Assessment* | A ranked list of one's notes that prompted a given type of interaction with specified frequency, and the details of each interactions |

The Knowledge Connections Analyzer

A special feature is that while many CSCL analyses tools are designed for researchers, this system is designed for teachers and students. Therefore, the KCA employs representations such as pie charts and bar graphs that are familiar to secondary school students and teachers. For example, we use pie charts and bar graphs to present the linkage of collaborators rather than employ complex social network grams that often used by researchers. To provide a better picture of the KCA system, we present sample results from KCA analyses for three of the questions.

Are We Collaborating?

Figure 1 presents sample results from a class of 38 secondary school students. The pie chart shows that 53% of students had at least five fellow students build on at least one of their notes. The bar graph on the right shows the exact number of students who built onto the notes of each of these students (e.g., six students built onto the notes of TKP 1A01, and 22 onto the notes of TKP1A33).
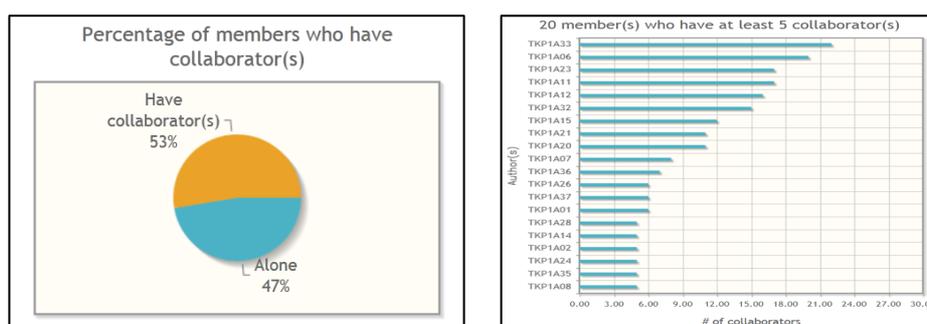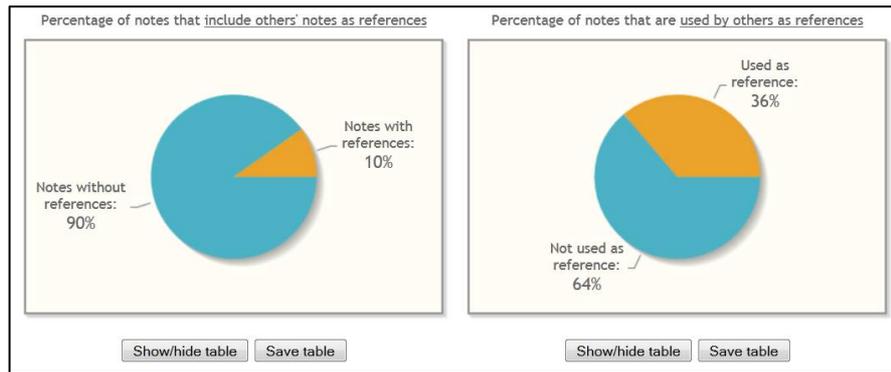

Figure 1. Sample view of "Are we collaborating" analysis results.

Are We Putting our Knowledge Together?

The pie chart in Figure 2 (next page) shows the results for a database in which 10% and 36% of notes contained and were used as references, respectively. The table in the lower part of the figure reveals that many of the links were created in an effort to provide synthesis (e.g., "Summary – The set of notes begins …" and "as I go through all the comments from teachers….""). By providing both statistics on and the details of notes in which references occur, we hope to make possible conversations about both the extent and quality of referencing practices.

How Do Ideas Develop over Time?

The pie chart in Figure 3 shows the results for a database in which 96% of notes were read by at least 2 times. The list on the top right shows the keywords emerged during selected period with the frequency of usage in the bracket. Clicking any notes that within the 96%, we could see the detail of the notes, in which keywords are highlighted and scaffolds in use are shown.

Figure 2. Sample view of "Are we putting our knowledge together" analysis results.
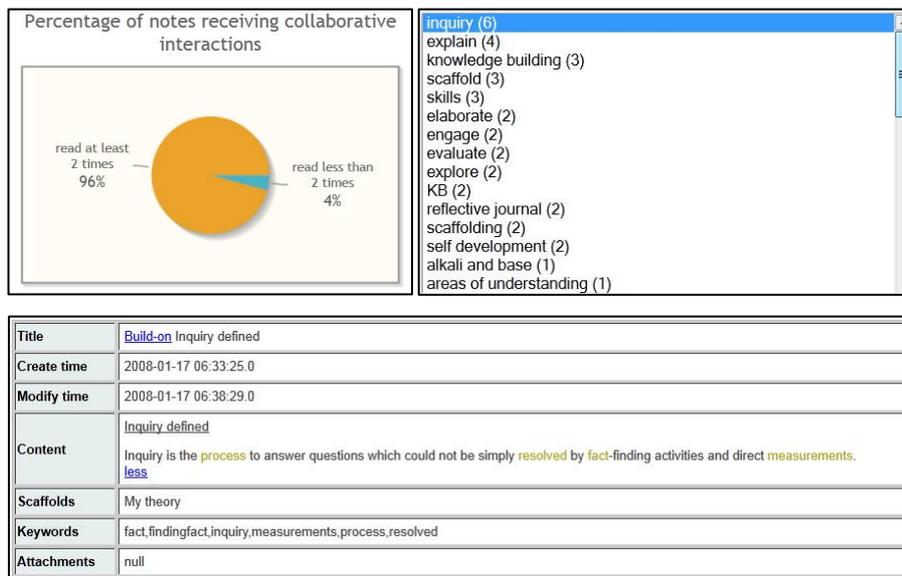

Figure 3. Sample view of "How do ideas develop over time" analysis results.

Testing and Improvement

We carried out three phases of usability testing on the KCA to check the accuracy of the analyses and determine whether teachers and students find the system and its analyses useful. First, the accuracy of the SQL database was compared with the results of an older tool written in Perl, the Analytic Toolkit (ATK) for Knowledge Forum® (Burtis, 1998), which has been used extensively in the past decade and garnered considerable confidence in its accuracy among teachers and researchers. The SQL results had an overall acceptable error rate of less than 5%. Second, we invited teachers' feedback at several points and made improvements to the KCA based on their comments. For example, we added a function to enable teachers to export results files to an electronic spreadsheet. Third, we conducted a small-scale field test in two classrooms, involving 10 randomly selected students from each class. The teachers liked the interface and found the KCA easy to use, informative, and efficient. The students found the tool easy to use and gave them fresh perspectives for assessing their performance on Knowledge Forum®. They said during interviews that they could interpret the results in relation to their knowledge building dynamics. Due to the length limit, detailed findings and discussions are not adequately addressed in this paper.

Conclusions and Implications

This paper reports on the development a formative assessment tool which focuses on the use of Knowledge Forum® server data to provide *students and teachers* with information about their knowledge building dynamics for self-assessment and reflection. The results from the preliminary testing of the KCA with a small sample of middle-school students are encouraging. After improving the system design based on usability testing feedback, we are currently using the system in larger classrooms to study how teachers and students use it to improve their knowledge building.

Based on proposed conceptual framework, KCA provides analysis on four general questions students may have about their online discourse. The four questions discussed herein are motivated by knowledge-building theory, but their application is not limited to it. Having an audience, synthesis, idea improvement, and understanding why some contributions make an impact and others do not are relevant to almost any approach to CSCL. However, they are crucial to knowledge building whose discourse occurs primarily (although not exclusively) online and over a long period of time. Knowledge-building inquiries can be sustained for months (Zhang et al., 2007), whereas typical problem-solving episodes in CSCL approaches require considerably less time. Further, although the SQL database is based on a Knowledge Forum® tuplestore, it would not be difficult to create versions that can be applied to other environments, such as Moodle®.

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