# Making a Difference: Analytics for Quality Knowledge-Building Conversations

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**Abstract:** The symposium focuses on the analysis of the knowledge building process e.g. idea improvement conversations by which students get to a high quality of knowledge and understanding. Learning Analytics (LA) focuses on the collection, measure and analysis of data about learners and their contexts (Long & Siemens, 2011). LA tools are normally rooted in probabilistic/frequency-based approaches. These are themselves incapable of capturing the meaning of texts at any level, because probabilities do not constitute natural language semantics. Therefore, semantic related analytics seems to be a promising approach. Not only to get insight in the process of knowledge building as a support for students and teachers in this collective process but also as a possibility for assessment. Not to control but to mirror and feed forward the semiotic collaborative process of building an understanding that makes a difference for how students look at and act in our world.

## The overall focus of the symposium

The aim of the symposium is to explore how recent development in learning analytics (LA), especially semantic and network analytics, could afford new understandings of knowledge-building discourse, so as to broaden its access to more classrooms with less tradition of or less support for the Knowledge Building pedagogy (Scardamalia & Bereiter, 2014). Underlying this aim is another effort to turn decades of research on knowledge-building dialogues into actionable analytics, to form a solid basis for further development of analytics *for* instead of *of* knowledge building.

Knowledge building (Bereiter, 2002; Bereiter & Scardamalia, 2006a) or knowledge creation (Nonaka, 2006; Nonaka & Toyama, 2003; Nonaka, 1994) consists of the social and group dynamic processes as is the case in collaborative learning. However, the latter does not always include the systematic, methodological, hermeneutic process of knowledge creation as an enculturation in Popper's world 3 (Magee, 1974). Despite the affordances of collaborative learning formulations such as scripts (Dillenbourg & Hong, 2008), roles (Strijbos, 2004), or orchestrating graphs and workflows (Dillenbourg, 2015), they do not support such an enculturation as required for knowledge building. While tools in knowledge-building environments have been developed and continually refined to support such enculturation into World 3 (Scardamalia, 2004), LA introduces new opportunities to catalyze this same kind of development.

According to van Aalst, (2009, p. 260) knowledge creation involves more than the creation of new ideas; rather, it requires discourse (talk, writing, and other actions) to determine the limits of knowledge in the community, set goals, investigate problems, promote the impact of new ideas, and evaluate whether the state of knowledge in the community is advancing. It goes beyond the knowledge sharing among students, as well as "knowledge construction [that] refers to the processes by which students solve problems and construct

understanding of concepts, phenomena, and situations" (p. 261). Knowledge creation, in contrast, involves the production and continual improvement of conceptual artifacts to solve authentic problems for community advance (Bereiter, 2002; Scardamalia & Bereiter, 2003). Knowledge building as a pedagogy engages students directly in the process of knowledge creation and help them "acquiring competence in knowledge creation by actually doing it" (Scardamalia & Bereiter, 2014, p. 399). Knowledge building derives from a Popperian epistemology and ontology (Bereiter, 2002; Scardamlia & Bereiter, 2014), with the Popperian ontological World 3 underlies the *semiotic process* in knowledge building. The World 3 enables knowledge production and sharing because we can grasp the knowledge in its form as a conceptual artefact, build on it, modify it, and develop it further. It concerns an objective knowledge world, created by the human mind. Students' thinking is related to their being-in-the-world and their mental mind(s) are embedded in their out-in-the-world artefacts.

Knowledge building as going into the artefact and the artefact getting into our minds is a process of transformation of our frame of reference. This process is a starting point for opening up our mind to perceive signs, codes and information as they manifest themselves in our problem, question, complexity. It is this semiotic process of noticing difference and potentials that we never perceived and understood before. *It is these kinds of knowledge building conversations with the others in the artefact, and with others about the artefact in which relations, e.g. differences come into language in the conversation (de Jong, 2015).* Not as an individual property of the interlocutors. 'What is', is 'laid down in the middle' as a 'rising above' in collective, in community, as a common language of collective understanding (a hermeneutic 'collective Verstehen'). The knowledge building conversation is not an adjusting to each other as partners in the conversation. Partners become engaged in the artefact, coming under the truth of the matter or praxis, under the resonation of understanding reality. A resonance of organic connectedness and dependency of our being as part of others and nature. Resonations that partners in the knowledge building conversation combine in a *new* common ground. In the 'knowledge-building-conversation' it is not merely against each other and putting your own positions forward, but a transformation into the common, into the collective. A transformation in which one does not remain who one was. (Gadamer, 1975, p. 360).

It is this *semiotic process* in which semantic learning analytics try to provide more empirically based insights. An approach that might be a basis for a direction of assessment. Instead of only assessing the grasp of facts it could move towards assessing the process of meaning making, thinking, and knowledge creation. Such an (formative) assessment by LA mirroring data and illuminating knowledge creation dynamics might help students in their process of thinking and becoming knowledge workers, and helps teachers to become knowledge building teachers.

This symposium addresses the question of how to develop these kinds of LA's to foster the support of assessment *for* students' understanding instead of assessing *of* students' learning and to support the students and teachers in the Knowledge Building process.

## How contributions to the symposium are contributing to the aims?

The contribution from Zhang et al. shows how 'Idea Thread Mapper' explicate the idea threads as an inquiry of a shared epistemic object and the 'journey of thinking' mirrors the syntheses of the epistemic endeavor, the absences of knowledge to be addressed by the community, the interrelated strands of inquiry and student's participatory roles. The contribution of Velazquez et al. applies Natural Language Processing (NLP) techniques to analyzing the coverage of syllabus' vocabulary in students' conversations is evaluated using a method based on linguistic and cognitive knowledge. The analysis uses an asymmetric coverage hybrid measure, which combines semantic and lexical information with cognitive principles to determine how syllabus' concepts are covered in students' conversations. VandenEnde et al. study used the same students as Velazquez and integrates students' socio-cognitive openness, their use of curriculum keywords in the knowledge building and the alignment of keywords in students' term paper. The contribution of Chen attempts to integrate the activity theory with recent innovations in *dynamic network analysis* (DNA) to derive new indicators of knowledge-building discourse. The contribution from Chan et al. presents the Knowledge Connections Analyzer, a software designed to support students' self-assessment of asynchronous online discourse that emphasizes the collective aspects of knowledge building.

## Idea Thread Mapper and its analytics tools: Tracing and connecting unfolding strands of inquiry across knowledge building communities

Jianwei Zhang, Mei-Hwa Chen, Feng Chen, and Carolyn Rosé

In a knowledge building community, students need to take on high-level collective responsibility for monitoring and continually advancing the "state of the art" of their collective knowledge (Scardamalia, 2002). Instead of

simply dealing with teacher-assigned topics and tasks, students identify deepening goals as their knowledge advances through knowledge building discourse, and co-construct unfolding strands of inquiry to address shared goals. They co-engage in "dual construction" to both construct knowledge and the socio-epistemic structures of knowledge practices to guide and sustain their ongoing interactions (Hakkarainen, 2009; Zhang & Messina, 2010; Tao & Zhang, 2016). Current analytics and assessment tools mostly focus on features of specific idea entries in knowledge building discourse (e.g. words, problems, claims, evidence) (Mu et al., 2012). This paper presents our design and research of Idea Thread Mapper (ITM) (Zhang et al., 2012; Chen M.-H., Zhang, & Lee, 2013) that captures collective structures and unfolding strands of knowledge practices reflected in long-term online discourse in order to inform students' purposeful contributions and connected efforts.

On top of micro-level representations of ideas using online postings and build-on's (physical conversation threads), ITM incorporates "idea threads" as an emergent structure in online discourse. Each idea thread includes a sequence of discourse entries (possibly several build-on trees) that investigates a shared epistemic object of inquiry (e.g. conductors), as an unfolding strand of inquiry work (Zhang et al., 2007). Features of ITM signify collective structures of knowledge building including (a) using the thread topics and "Journey of Thinking" syntheses to highlight the shared epistemic objects being investigated and absences of knowledge to be addressed by the community; (b) using timeline-based discourse mapping to visualize the unfolding, interrelated strands of inquiry practices focusing on the epistemic objects; and (c) retrieving members' participatory roles in the different strands of inquiry. The collective landscape of a whole knowledge building initiative is mapped out as clusters of idea threads that investigate a set of interrelated problems through the contributions of all members. Visualization tools further show the intensity of contributions in each thread and cross-thread connections, including cross-thread build-on links and connective contributions that simultaneously address two or more objects of investigation.

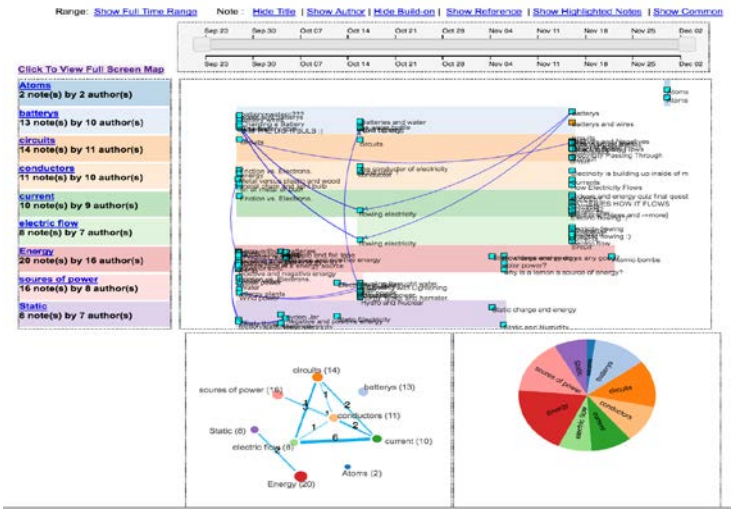


Figure 1. A map of idea threads created by a Grade 5/6 classroom studying electricity. Each colored stripe represents an idea thread extending from the first until the last note contributed. Each square represents a note; a blue line between two notes represents a build-on link. The example analyses (bottom) show the distribution of notes in the different idea threads and conceptual connections between the threads.

ITM integrates a set of automated analyses to support students' construction and review of idea threads in online discourse. Text analysis models set up using LightSIDE (formerly known as TagHelper — see Rosé et al., 2008) based on human-coded data can identify online discourse moves (contributions types) such as questioning (Kappa = .80), referencing sources (Kappa = .72), theorizing (Kappa = .68), and using evidence (Kappa = .52). An augmented Latent Dirichlet Allocation (LDA) tool retrieves topics from student online discourse in relation to topical structures of relevant expert texts (i.e. Wikipedia) and recommends online posts most relevant to each topic, as a potential idea thread. A cross-community space is further provided for students to share (publish) productive idea threads and "Journey of Thinking" syntheses across classrooms, with analytics of semantic similarity facilitating potential cross-community connection and complementarity.

ITM-supported classroom designs engage students in reflexive monitoring and structuring of knowledge building and formative assessment for collective and individual progress. A set of studies was conducted in third- through sixth-grade classrooms. The ITM-aided reflective monitoring and structuring of online discourse played

a positive role in increasing student awareness of their community's evolving focus and collective progress, leading to more connected deepening moves to generate deep and coherent understandings (Chen, J. & Zhang, 2016; Tao et al., 2015; Zhang et al., 2015). Reviewing Journey of Thinking syntheses from other classrooms helped students to reflect on their own idea progress and gaps and further integrate insights from different communities for deeper research.

## Analyzing students' knowledge-building conversations by comparing to syllabus and their collective writing

Erick Velazquez Godinez, Sylvie Ratté, Frank de Jong, Joan van den Ende, and Hennie van Heijst

Learning analytics (LA) has emerged during the past five years as a means to analyze mainly quantitatively the 'Learning' process. Mostly, LA focuses on frequencies of participations, contributions, amount of references, etc. (De Jong, 2015). Considering recent advances in Natural Language Processing (NLP) and Text-Mining (TM) techniques, it is now possible to incorporate new models within LA, to study the students' development of new concepts within knowledge-building dialogues. This, hence, provides an insight to both, teachers and students. Recent works on the analysis of learners' dialogues in CSCL platforms have shown that various linguistic and cognitive phenomena are involved in the learning processes (Dascalu et. all, 2015; Scheihing,et. all., 2016).

A lot of the works in computer science have been focused on similarity as a symmetric relation (Landauer, McNamara, Dennis, & Kintsch, 2007). These similarity measures were conceived in a symmetric way because of the use of geometric spaces, like Vector Space Model (VSM), and the bag of words model for cosine similarity in the context of NLP. When comparing two objects, A and B, in a coordinated space, this kind of similarity is symmetric because the distance is always the same from object A to object B and vice versa.

However, Tversky and Itamar (1978) standpoint is that similarity is an asymmetric relation, better described as a comparison of features (matching process) rather than a computation of metric distances between two points (Pinker, 2013). Tversky et. all. also, mentions that the concept of symmetric similarity should not be rejected altogether; it holds in many contexts, while in many others it is a useful approximation. He highlighted that symmetric similarity cannot be accepted as a universal principle of psychological similarity. Moreover, he shows that the concept of asymmetric similarity was observed in production tasks where we generate a similar response against single stimulus. Examples of these tasks are pattern recognition, stimulus identification, and word association.

An experiment was conducted, where conversations of four students in the Knowledge Forum were compared to the syllabus and a theme product. The syllabus is composed by 9 documents. These are all conference or journal articles. The theme product document is a collective document that the same group of students elaborated. The group consisted of 4 Med 'learning and innovating' students following the 3 month them 'visons on learning' as part of the 2 years' part time MEd 'learning and innovating' program. Students' years of age was 26, 24, 43. The two women students are teachers with many years of work experience the male student is director of an advisory enterprise in the field of 'ecology and landscaping'.

The conversations concern contributions of students in the Knowledge Forum environment. The number is different per student. The length of the contribution differs per contribution. The analysis concerns the use of concepts from the syllabus reflected in the students' conversations and their collective term paper, e.g. their conceptual artefact of their vison of learning conceptualized in a textual augmented visual model. The Dutch conversation data where translated with Google translate and corrected for spelling, typing errors etc. Stop-words were extracted. Finally, we face the problem of concept coverage by using a similarity text computation. For this we use the ACHM (Velasquez, Ratté, and de Jong, 2016). When comparing a syllabus text and a student's text, the ACHM allows selecting the word of the syllabus that contributes the most to the computation of the similarity process with the student text. This word is assumed to be the concept that ensures the connection between both segments of texts.

In analyzing the conversations versus the syllabus, a scatterplot is used to show the coverage value on the Y-axe. The X-axe represents the index of the student collaboration. The points that we can see for each student contributions in Fig. 2 (left) represent a different book from the syllabus. For example, the contribution one of the student 3 is almost aligned with almost all the syllabus document with a high degree of coverage. In more personal graphs like in Fig. 2 (right) the related articles of the syllabus of the concepts that are coming into the conversation of a student is presented. On the Y-axes, the index coverage is presented.

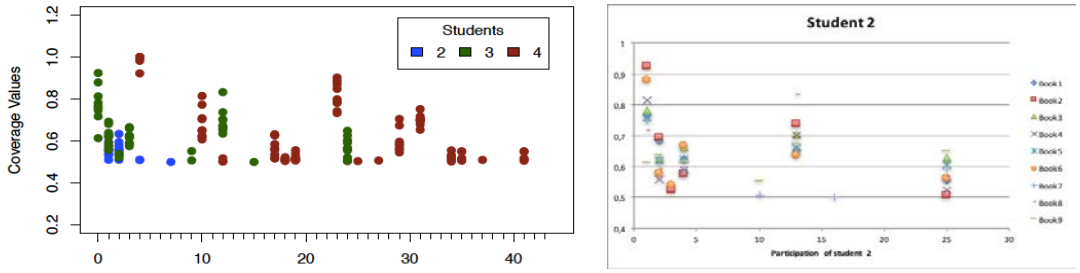


Figure 2. (left) Concentrated graph of student contributions and alignment with the syllabus; (Right) Dots express concepts from a particle syllabus article. On the Y-axes the similarity index and on the X-axes the contributions in time order.

The analysis shows the difference between students' contribution in the amount of similarity e.g. the covering of the syllabus' concepts by the conversations and the coverage of the term paper concepts by the conversations. This study gives insight in on the one hand in what way 'authoritative sources' contributes to the building understanding in the conversation and on the other hand how the conversations contribute to the term papers, e.g. the students' conceptual artefact concern their collective vison on learning.

## Key concepts and socio-cognitive openness: Exploring the potential of knowledge building from the two perspectives

Joan van den Enden, Hennie van Heijst, Frank de Jong, Yoshiaki Matsuzawa, and Paul Kirschner

As teacher-researchers in an MEd program 'learning and innovating' we build our pedagogy on the principles of knowledge building and responsive learning (de Jong 2015). To improve our educational practices, we are constantly looking for more insight into how the knowledge building discourse in student communities fosters the development of a collective product (e.g., conceptual artifact; Bereiter 2002). To this end we conducted an in-depth case study on the knowledge building process of four students within a community of 28. These students are the same as in the Velazquez et al. study. We addressed the following questions: How do key concepts in the literature and in the collective term paper about a model of learning, enter and evolve in the knowledge building discourse. In this case study (N=4 students, 79 contributions in 19 conversation initiatives of which 12 developed; 3 rise aboves) we analyzed the: (1) emergence of key concepts in the online discourse itself, (2) use of key concepts in the final conceptual artifact, and (3) degree of socio-cognitive openness of the online discourse. For the key concepts we used KBDeX (Knowledge Building Discourse eXplorer), a tool to explore network structures of collaborative learning discourses in Knowledge Forum from the perspective of social as well as semantic analysis (Matsuzawa, Oshima, Oshima, Niihara, & Sakai, 2011). To analyze the degree of openness, we used a coding scheme based on CSCL-literature.

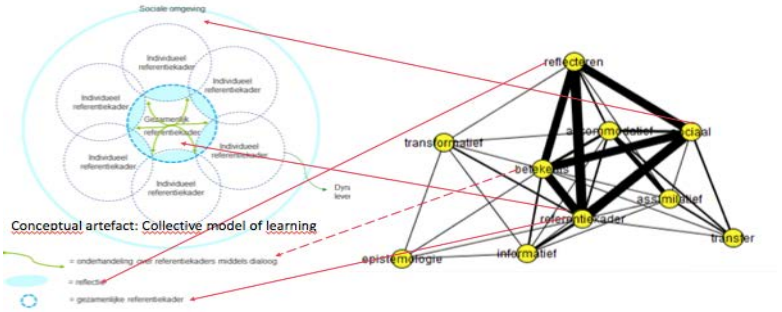


Figure 4. Alignment of key concepts in discourse and in collective term paper.

Conclusions: At the beginning stage at group level all key concepts appear and are loosely connected. There seems to be a fair amount of openness, although individual students show a diverse appearance of key concepts. During the process of knowledge building at group level, a selection of key concepts is firmly connected and a larger amount of openness is realized. More openness based on expression is showed at the individual student level; Students also show varying levels of uncertainty expressions. We determined an interaction with

the degree of participation in the conversation. In the final stage, the selection of key words is slightly expanded at group level and can be easily recognized in the collective product, though the phrasings are different (see Fig. 4). The openness slightly diminishes except for orientation towards the other members. At the individual student level, student B develops the most strongly connected key words network, participates most and shows best balanced emergence of openness. Student C, who participated least, developed a scattered key words network but expressed greater openness. Student A participates at a 'medium' level and expresses least openness of all.

## Deriving knowledge-building analytics through activity theory and dynamic network analysis

Bodong Chen, & Yoshiaki Matsuzawa

Knowledge Building (KB) is conceptualized as an interactive system involving epistemic agents (e.g., students, teachers), knowledge objects, and sociocultural practices (Chen & Hong, 2016), with KB principles (Scardamalia, 2002) explicating the relations among them to distinguish KB from other pedagogical approaches. For example, the principle of *Improvable Ideas* stresses the ontological substance of ideas, the commitment of epistemic agents to improve them, and the sociocultural norms of tolerating tentative ideas and continually improving them. To derive analytics for KB, therefore, efforts need to be geared towards understanding and interpreting the intricate relationships among agents, knowledge objects, and practices.

So far, much work has committed to the extraction of various measures from KB discourse (Burtis, 1998; Oshima, Oshima, & Matsuzawa, 2012; Zhang & Sun, 2011). While these techniques have shown promise in understanding KB discourse from unique angles, a more holistic approach that addresses the interactive KB system could contribute to the ongoing effort of developing KB analytics.

Among existent efforts to analyze KB discourse, the use of *activity theory* (Cole & Engeström, 1993) as an analytic framework represents a promising approach that "simultaneously" lights on multiple factors in KB discourse (Hewitt, 2004; van Aalst & Hill, 2006). Originating from Vygotsgy's work, activity theory attempts to bridge the space between *subjects* (e.g., students) and *objects* (e.g., tasks, problems of understanding) by recognizing various mediational means in between, i.e., *tools*, *rules*, *community*, and *division of labor* (Cole & Engeström, 1993). Compared to quantified content analysis widely applied to the analysis of KB discourse, the activity theory framework could afford a richer description of KB discourse, "because it accounts for both individual and communal activity, as well as multi-directional movement of individuals within the community" (van Aalst & Hill, 2016, p. 25).

During this session, we will present an emerging approach of operationalizing such activity-theory analysis through *dynamic network analysis* (DNA) and *rapid ethnographic assessment* (Carley, Bigrigg, & Diallo, 2012). Compared to a typical one-mode social network, a dynamic network is multi-mode (involving different types of nodes such as students and concepts) and multi-plex (comprising different kinds of links) network to capture different aspects of a KB activity system. Specifically, we first seek to construct a network representation of *subjects*, *objects*, *artifacts*, and *division of labor* (instructive to not cover *rules* and *community* for now) from trace data in Knowledge Forum; the resulting dynamic network is a holistic, theoretically-informed representation of KB discourse ready to be interpreted from different angles. Then, we can derive measures for different factors in the activity system, as well as the interactions among them. Using a simple example, we can derive a measure for *subjects* in a KB dialogue based on the count of Knowledge Forum activities from all students and the sum of connections they form with domain-specific concepts. This approach is distinctive from earlier work in CSCL that embraces a reductionist approach (Xing, Wadholm, Petakovic, & Goggins, 2015) or focuses on two-mode networks (Andrade, 2015).

A case study based on a secondary dataset (see Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007) will be presented, to afford opportunities for triangulation and validation. Analytic decisions will be critically examined, together with future development of this approach in machine learning, pedagogically responsive analytics, and information visualization for sense-making.

## Using knowledge connection analyzer to scaffold reflective assessment in knowledge building

Carol Chan, Jan van Aalst, and Christine Yang

Knowledge building is a pioneer model in CSCL and an educational approach to initiate students into a knowledge creation culture (Scardamalia & Bereiter, 2014); a key idea is the contribution to the community for sustained idea improvement. At the heart of knowledge building is the online progressive discourse, supported by

Knowledge Forum® that help students maintain focus on idea improvement during their note-reading and note-writing as they work with ideas. Increased attention has been given to analysis of collective progress in knowledge forum discourse (Hong et al., 2015). Our goal is to employ the use of assessment and learning-analytics data in knowledge building for *formative assessment;* data extracted are to help students to self-assess and reflect on their discourse for progress. We present research using the Knowledge Connections Analyzer (KCA, Van Aalst et al. 2012), a software designed to support students' self-assessment of asynchronous online discourse that emphasizes the collective aspects of knowledge building (see Fig. 5).

A key goal of the KCA is to enable students to develop an understanding of knowledge building as involving effort and achievements at different levels—from the individual level to the community (or whole class). As pointed out by Stahl (2010), learning in a community produces *group cognition*, which is not reducible to the efforts of individual students. KCA attempts to help students understand and bring the collective aspects of knowledge building into focus. It is designed around four intuitive questions; students can run KCA and reflect on these questions: 1) Are we a community that collaborates (extent to which students are collaborating with others); 2) Are we putting our knowledge together? (use of reference notes in meta-discourse); 3) How does the community knowledge develop? (using keywords to identify key themes of community interests) and 4) What is happening to my own contributions? (tracking how own ideas develop over time) (Van Aalst et al., 2012)

We conducted initial research on KCA analyzing several Knowledge Forum databases drawn from the knowledge-building teacher network in Hong Kong (Chan, 2011), classified into two groups (Group 1: DB1, DB7, DB8, and DB9) and Group 2 (DB2, DB3, DB4, DB5, DB6); *analysis* shows that databases with stronger design work (i.e., principle-based portfolio) showed stronger KCA data on collaboration and rise-above compared to more novice teachers; the comparison data help validate KCA data and identify patterns where deeper knowledge work and conceptual synthesis are needed.

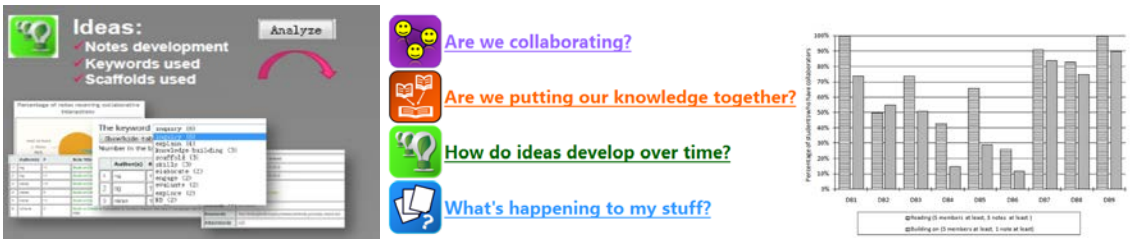


Figure 5. (Left and Middle) Features of Knowledge Connection Analyzer; (Right) KCA indices of community connectedness for nine databases with different intensity of pedagogical designs.

This study includes 32 grade-10 visual arts students working on knowledge building in a Hong Kong classroom. After the initial weeks on writing on Knowledge Forum, they were scaffold with the use of KCA to reflect on their KF discourse; it includes both teacher-researcher running KCA and students running KCA in groups to obtain data to track their own knowledge building work. Quantitative analysis shows how the use of KCA helped students to improve on Knowledge Forum discourse including the use of build-on and reference notes as well as qualitative coding of ideas showing more sophistication. Qualitative analysis of classroom discourse suggests how teacher scaffold students and how students engage in reflective assessment examining the gaps in current work, and in particular the collective aspects of knowledge building and how they could move forward (e.g., discussion on patterns of reference notes generated from KCA and need for more rise-above ideas). Knowledge-building talk and forum discourse have been the key areas of attention in knowledge building classrooms; the use of KCA additionally help students focus on data-driven improvement of discourse and transformative assessment as a collective cognitive responsibility.

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