A Learnable Content & Participation Analysis Toolkit for Assessing CSCL Learning Outcomes and Processes

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Abstract: In this paper, the authors first review the different kinds of analysis methods used by researchers to assess students' learning outcomes and processes to propose a categorization framework that can be applicable for assessment methods of CSCL discourse irrespective of the theoretical underpinning of the assessment method. A conceptual design for the construction of a suite of learnable content and participation analysis tools is proposed to provide intelligent support to analysis of online discourse. It is argued in this paper that the implementation of such a toolkit will facilitate collaboration and critical co-construction of knowledge about CSCL outcomes and processes among researchers. An example is also provided for the use of VINCA, a prototype for the toolkit, in comparing the cognitive engagement of two groups of students through text analysis.

Introduction

Since the launch of the World Wide Web in 1991, the use of CMC to support learning has taken flight and its importance as a field of study is increasing rapidly. There is a wide coverage of research interests and diverse theoretical and methodological approaches adopted in this burgeoning field of research. While there is no lack of descriptions and reviews of methods and indicators used to analyze online discourse data, the challenge of finding an appropriate set of instruments for specific purposes in CSCL research has not become easier. In fact, it is not even easy to compare and learn from the findings of research conducted by different researchers because of the great methodological diversities. *Computers & Education* published in 2006 a special section on methodological reviews of CSCL research that highlighted issues of accuracy, validity and reliability of the methods adopted (Valcke & Martens, 2006). Any attempt to make methodological categorizations for CSCL research is extremely difficult and many different approaches can be found in the literature (e.g. De Wever, Schellens, Valcke, & Van Keer, 2006; Dringus & Ellis, 2005; Mason, 1992; Rourke, Anderson, Garrison, & Archer, 2001; Strijbos, Martens, Prins, & Jochems, 2006). There are several key underlying characteristics of the researches that contribute to the methodological diversity and complexity of CSCL research: diversities in the researchers' theoretical underpinnings (De Wever, Schellens, Valcke, & Van Keer, 2006), their different research interests which span learning outcomes and learning processes of various kinds as well as mechanisms and models of collaborative learning. The greatest complexity relates to methodologies used in content analysis of discourse data. There is great diversity even in terms of the unit of analysis which can vary from a sentence to a paragraph, to a thematic unit, to a message or even a discourse (De Wever, Schellens, Valcke, & Van Keer, 2006; Strijbos, Martens, Prins, & Jochems, 2006) and reliability is a great challenge even for segmentation of analysis units.

This paper argues that there is a need for two kinds of tools to facilitate communication and co-construction of knowledge in the community of CSCL researchers: a common set of descriptors that researchers should provide to report on their methodologies and analyses results irrespective of their theoretical underpinnings; and a suite of learnable content and participation analysis tools to facilitate collaboration and critical co-construction of knowledge about CSCL. The next section proposes a framework for categorizing methods used to analyze the learning processes and learning outcomes in CSCL settings with illustrations from published research. This categorization framework will provide a set of descriptors that researchers could use when they report on their methodologies and analysis results. Based on this framework, this paper goes on to describe the conceptual design for a suite of analysis tools and extensible knowledge bases that would provide intelligent support to the researchers in analyzing learning processes and outcomes and indicators proposed. The suite of tools would be capable of "learning" such that the performance of the tools in its effectiveness as an intelligent support would improve through continuous enhancement of the knowledge base through use. The analysis results and the knowledge base derived from the use of such intelligent tools by different researchers can also be compared to facilitate comparison of different research approaches and methodologies. Finally, VINCA, a prototype for such a suite of tools will be briefly described.

Methods for Analyzing CSCL Processes & Outcomes: a Categorization Framework

To date, research in the area of CSCL may be underpinned by a variety of theoretical subscriptions. However, the purposes are relatively similar, and can be grouped into three categories based on the kind of research questions they ask. One category is the "*what"* questions – what have students learnt in this process. This could include cognitive, metacognitive and sociometacognitive outcomes. The second is those addressing the "*how*" questions and six dimensions can be identified in the published research in characterizing the CSCL process: participative, social, interactive, cognitive, metacognitive and sociometacognitive. The last category is those addressing the "*why*" questions to explore theoretical models of CSCL, how the process indicators may be related to the outcome indicators. Obviously, not only the *why* questions are strongly underpinned by the theoretical subscriptions of the researchers, but also the formulation of what counts as indicators for the *what* and *how* questions. On the other hand, irrespective of the theoretical underpinnings, the direct outputs from the analyses of discourse data, whether the methods adopted are quantitative or qualitative, are indicators for the learning outcomes and/or the learning processes (i.e. indicators for the *what* and *how* questions). Answers to the why questions are constructed by researchers on the basis of these two kinds of indicators. Furthermore, the same set of indicators may be used in different researches that adopt different theoretical perspectives and/or address different *why* questions.

Table 1. A categorization framework for methods of analyzing CSCL processes and outcomes illustrated with examples drawn from published research.

	Methods, indicators & examples of use		
What (learning outcomes)			
Cognitive	Quality of constructed knowledge using SOLO taxonomy (unistructural, multistructural, relational & extended abstract) (Veldhuis-Diermanse, 2002)	Critical thinking (+ve & -ve indicators for 10 categories: novelty, relevance, importance, linking ideas, justification, critical assessment, practical utility, etc.) (Newman, Johnson, Webb, & Cochrane, 1997)	
Cognitive/ Metacognitive	Critical thinking (+ve & -ve indicators for 4 categories: clarification, inference, judgment & strategies) (Bullen, 1998)	Categories of knowledge construction (new ideas, explanations & evaluation) (Veerman & Veldhuis-Diermanse, 2001)	
Sociometacognitive	Phase of knowledge co-construction (Gunawardena, Lowe, & Anderson, 1997)	Level of knowledge building (Law & Wong, 2003), (Law, 2005)	Level of discussion (higher-level, progressive & lower-level discussions) (Jarvela & Hakkinen, 2002)
How (learning processes)			
Participative	Level of participation (no. of messages) (Henri, 1992)	Density, intensity (Fahy, Crawford, & Ally, 2001)	
Social	Socially oriented statements (Henri, 1992)	Social presence (affective, interactive & cohesive responses) (Rourke, Anderson, Garrison, & Archer, 1999)	Stage of perspective taking of discussion (undifferentiated & egocentric, differentiated & subjective role-taking, self-reflective & reciprocal, 3rd person & mutual, in-septh & societal-symbolic) (Jarvela & Hakkinen, 2002)
Interactive	Social network analysis (Aviv, Erlich, Ravid, & Geva, 2003; Palonen & Hakkarainen, 2000)	Vertical & horizontal interactions (Zhu, 1996)	Kinds of content exchanged, directedness (vertical questioning, horizontal questioning, statements & supports, reflecting, scaffolding, references/ authorities) (Fahy, Crawford, & Ally, 2001)
Cognitive	Cognitive skills (clarification - elementary & in-depth, inference, judgment, strategies) (Henri, 1992)		
Metacognitive	Metacognitive knowledge (about person, task & strategies) and skills (evaluation, planning, regulation & self-awareness) (Henri, 1992)		
Sociometacognitive	Knowledge building developmental trajectory (Law & Wong, 2003) (Law, 2005)	Types of interactions (questions – information seeking or dialogue oriented, answers to provide information, information sharing, discussion, comment, reflection & scaffolding) (Zhu, 1996)	

It is argued here in this section that a categorization framework for analysis methods and indicators applicable to a diversity of CSCL learning theories and research interests would be profitable for facilitating comparison, collaboration and critical co-construction of knowledge within the CSCL community at the three levels of research questions listed above. Table 1 presents one suggested categorization framework with examples of methods and indicators drawn from published research. We find that in terms of assessing learning outcomes, three categories of outcomes were targeted in the literature, cognitive, metacognitive and socio-metacognitive. An example of a scheme for assessing cognitive outcomes in the learning of specific contents or concepts is one used in Veldhuis-Diermanse (2002) which adopted the SOLO taxonomy developed by Biggs & Collis (Biggs & Collis, 1982; Zhu, 1996). However, we find that most of the analysis schemes for cognitive outcomes in the published literature do not focus on the learning of content or concepts but on assessing students' critical thinking ability. Further, we find that some of the indicators such as evaluation, judgment and strategies were considered as cognitive by some researchers (e.g. Bullen, 1998; Veerman & Veldhuis-Diermanse, 2001) but as metacognitive by others (e.g. Henri, 1992). Instead of assessing the learning outcome of individuals in the collaborative process, some researchers were interested in assessing the socio-metacognitive ability of a collaborating group to co-construct knowledge through discourse (e.g. Gunawardena, Lowe, & Anderson, 1997; Jarvela & Hakkinen, 2002; Law, 2005; Law & Wong, 2003).

Sometimes, CSCL discourse was analyzed to examine the learning processes that took place through the online discourse. Six categories of indicators for the learning process can be identified in the literature: participative, social, interactive, cognitive, metacognitive and socio-metacognitive. Examples of participation indicators are levels of participation (Henri, 1992) and the density and intensity of the discussion (Fahy, Crawford, & Ally, 2001). Indicators for the social dimension of the discourse include a simple count of socially oriented statements (Henri, 1992), presence of affective, interactive and cohesive responses (Rourke, Anderson, Garrison, & Archer, 1999) and the stage of perspective taking of the discussion (Jarvela & Hakkinen, 2002). Examples of indicators for the interactivity of the CSCL discourse include social network analysis (Aviv, Erlich, Ravid, & Geva, 2003; Palonen & Hakkarainen, 2000), presence of vertical & horizontal interactions (Zhu, 1996), the kinds of content exchanged and directedness of the discourse (Fahy, Crawford, & Ally, 2001). Indicators for the cognitive, metacognitive and socio-metacognitive characteristics of the discourse can also be taken as indicators for the respective kinds of learning outcomes at the points when the process data was captured. In fact, the cognitive skills and metacognitive knowledge and skills as defined by Henri (1992) bears similarity to the critical thinking skills indicators of Bullen (1998) and categories of knowledge construction indicators of Veerman & Veldhuis-Diermanse (2001) developed for the assessment of learning outcomes. Law & Wong (2003) coded the socio-metacognitive characteristics of CSCL discourses as outcomes reached at various points in time to track the developmental trajectory of groups. These indicate that CSCL researchers generally perceive learning process characteristics as important outcomes.

Several researchers have commented on the different units of analysis from sentences to thematic units, paragraphs, messages and discourses being adopted by different researchers when analyzing CSCL discourse (De Wever, Schellens, Valcke, & Van Keer, 2006; Rourke, Anderson, Garrison, & Archer, 2001; Strijbos, Martens, Prins, & Jochems, 2006). We find such differences to exist not only between analysis schemes for different categories of indicators, but also within the same category. For example Bullen (1998) used a message while Newman, Webb & Cochrane (1995) used a thematic unit as the unit of analysis for coding critical thinking as cognitive learning outcomes. So far, it is not clear what impact such differences have on the analysis results and findings. It is even less clear what kind of similarities or differences exist between different sets of indicators of the same analysis category.

It is proposed here that researchers should clearly indicate, for each analysis method they use, a categorization for the indicators (i.e. which of the learning outcome(s) and learning process(es) are these indicators measuring) as well as the unit of analysis employed as a basic nomenclature for methodological description. Such nomenclature would already facilitate easier comparison of assessment schemes and indicators. More importantly, if there is an assessment toolkit which can document the operationalization of different analysis schemes indexed according to this nomenclature, this toolkit would be able to present comparisons of analysis outputs from different schemes and methods and facilitate more in-depth methodological comparisons and discussions. Furthermore, if the assessment toolkit can have built-in intelligence to support analysis of CSCL discourse based on the input coding schemes and be able to learn from coding actions of researchers to derive and improve on the coding rules, this will greatly facilitate the sharing of knowledge and skills in discourse analysis and hence contribute significantly to advancement in this research area.

Towards a unified toolset for analyzing CSCL

There are different tools currently used by CSCL researchers for analyzing online discourse. However, there are several important inadequacies in the tools that we have available currently that make discourse analysis a tedious, inefficient and often ineffective process:

1. The tools for different analyses are not integrated so that lots of time is wasted in transforming data into different formats for the different analyses.
2. Quantitative indicators have been criticized to be insufficient to reflect the quality of learning (Meyer, 2004) and content analysis is necessary to provide deeper understanding of the learning outcomes and processes. However, the only tools that are readily accessible to support content analysis are qualitative data analysis tools such as ATLAS.ti or N-vivo. These tools support the definition of coding schemes, search, creation of coding indices and exploration of different logical combinations of codes. However, the coding process itself is still largely manual and the main coding support is to highlight selected keywords in the discourse text.
3. The qualitative analysis tools themselves are incapable of learning so that no matter how much discourse analysis has been conducted by the tool, it would not make the coding process any less tedious for the coder.
4. While researchers can share the coding schemes they have developed, there is no tool that can provide a mechanism for different researchers to share their coding expertise.
5. Participation and interaction indicators and content analysis codes are generated separately by different tools, making it much more difficult to conduct a sequence of multiple analyses on the same set of data. Examples of profitable multiple analyses include generating the social network for discourse associated with selected discourse units that exhibit characteristics of specific cognitive processes, and displaying the coding labels for discourse units from group members with a high centrality index.
6. Coding of CSCL discourse is based on the interpretation of the discourse texts. Text mining techniques thus has the potential of providing the backbone for semi-intelligent coding tools but such technology has not been incorporated in the commonly available content analysis tools.

Matrinez et. al. (2006) proposed a mixed-evaluation framework and a software suite to study the participatory aspects of learning in CSCL. Their work represented advances in designing software suites that bridges social network analysis with qualitative and quantitative analysis of interview and survey data to overcome some of the conceptual and technical challenges mentioned above. Donmez et al. (2005) reported on the successful deployment of the TagHelper technology in the supporting autonmatic multidimensional categorical coding of CSCL data. The work reported here is an effort to build on and extend related work in the area. In the following section we describe the design of an analysis framework and a suite of analysis tools with extensible knowledge bases that would 1) provide intelligent support to the researchers in analyzing CSCL discourse using analyses schemes that fit within this proposed categorization framework for assessment methods and 2) support comparison of analyses using different sets of indicators.

A Conceptual Design for Learnable CSCL Assessment Tools

Based on the above reviews, we have developed a conceptual design for a suite of learnable content and participation analysis tools for use in CSCL research (see Figure 1). At the core of this toolkit is a coding schemes and coding rules database which keeps a well organized set of coding schemes indexed according to the categorization framework presented in Table 1 above. The database also keeps record of the coding rules that have been used by various researchers for the same coding scheme and the coding effectiveness for those rules. The toolkit contains modules that can learn from coding operations to continuously improve the coding rules, as well as provide mechanisms for users to compare and/or to merge the coding schemes and/or coding rules developed by different users. The toolkit contains the following key components:

Preparatory Components

These components are designed to transform discourse data collected from any CSCL platform into a form that can be processed by the analysis tools and to provide a mechanism for users to define the coding schemes and coding rules. There are three main preparatory components:

Data Preparation Component

This component allows the user to take discussion data from a number of popular CSCL platforms such as threaded discussion, Wiki and Knowledge Forum® and transform automatically into a standard relational database format. It will also allow the user to define the data structure from unspecified discussion platforms so that the appropriate data preparation process can be performed. The resulting *discussion record database* stores basic information such as author, date and time of post, the threaded discussion structure, message title and message body. There is also a discourse selection component to allow the user to select a subset of the discourse data for analysis according to the authors, the time period of the discourse took place, or other characteristics as desired.

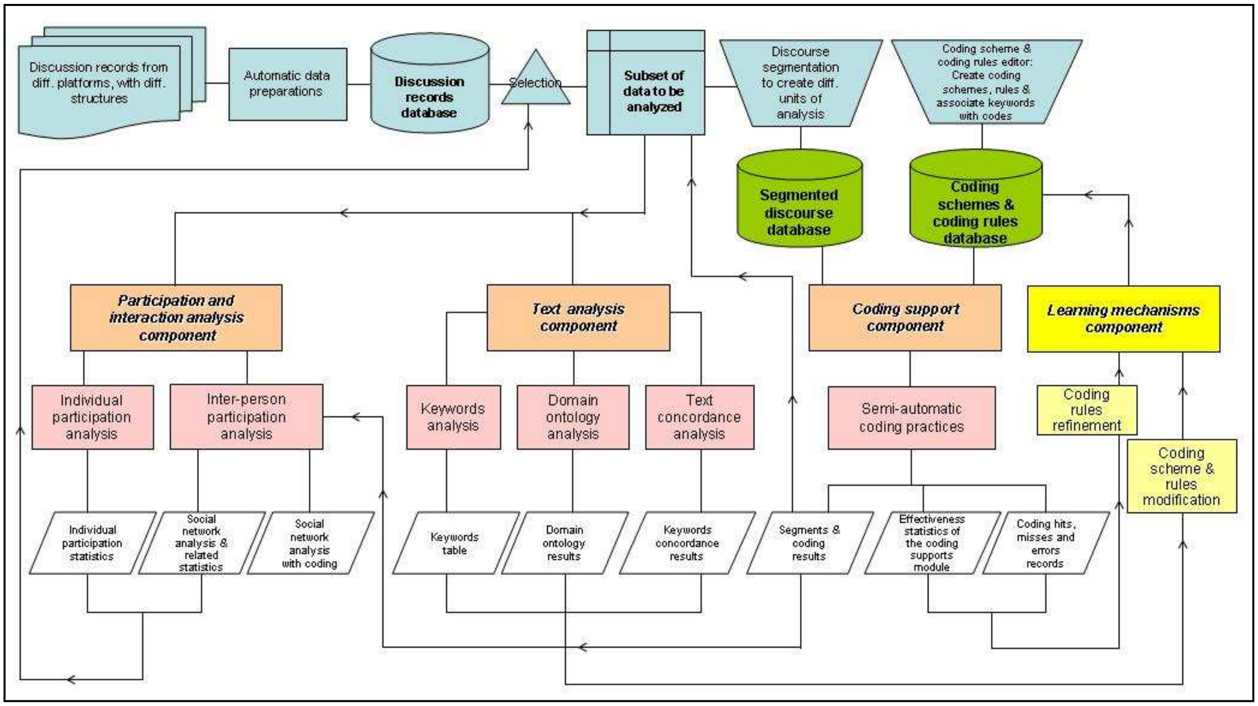

Figure 1. A conceptual design for a suite of learnable content and participation analysis tools for use in CSCL research.

Discourse Segmentation Component

This component allows the user to segment the discourse into appropriate units of discourse text for analysis. Thus the user can define the text units into sentences, paragraphs, themes, messages or any other units as the researcher finds appropriate. The output would be stored in the *segmented discourse database* ready for content analysis operations.

Coding Schemes and Coding Rules Editor

This editor will allow the user to create and store coding schemes and text pattern rules, which can be stored in the *coding schemes & coding rules database*. The coding schemes can have a hierarchical structure. Each code can also be associated with text patterns and other rules that user has found to have a high probability of being found in discourse text with that code.

Analysis Components

There are three main analysis components in this toolkit: the participation and interaction analysis component, the text analysis component and the coding support component. Each component may have several modules.

Participation and Interaction Analysis Component

In CSCL studies, researchers are interested in collecting user participation statistics at the individual and the interpersonal interaction levels. There are thus two modules in this component. The individual participation analysis module provides basic statistics on an individual's number of posts, replies, or number of keywords used in the discourse. For the inter-person participation analysis module, it can produce output data to generate social network analysis displays as well as statistics on interaction such as betweenness, centrality, clustering cohesion and so on. Using this same module, one should also be able to return participation and interaction analysis results for selected coded data, e.g. the individual participation statistics for discourse statistics showing high levels of critical thinking; or one could compare the centrality of the same group of participants for socially oriented v.s. inquiry oriented discourse.

Text Analysis Component

The modules in this component provide text analysis results that can help the user to formulate semantic analysis strategies on CSCL discourse data. One of the modules in this component performs keywords analysis. For any set of discourse data, this module can generate the list of keywords and key phrases used and the respective usage frequency. It can also compare the similarity between users in terms of their keywords usage. The second module performs domain ontology analysis. Very often, teachers and researchers are interested to know to what extend students' discussion overlaps with experts' or textbooks' conception of the focal content in the discussion. This module compares the domain ontology of the discourse with the concept map of the topic drawn by teachers or experts. Various statistics can be also be generated to reflect participants' performance, such as the similarity of the group's ideas when compared to the experts, individual members' contribution in terms of relevance of ideas, novelty of ideas, and extensiveness of ideas to the discourse. A third module in this component is the text concordancing module, which essentially allows the user to extract all text segments containing a keyword together with a user-specifiable length of text before and after the keyword. This is very useful since the semantic context of a piece of text cannot be clearly reflected by the presence of a single keyword or phrase. An example of how this module can be used to support further content analysis will be provided in the next section.

To summarize, the three types of analyses to be conducted by the modules in this text analysis component expose discourse dynamics at the semantic level. The outputs from the modules in this component in addition to being useful in themselves as a form of content analysis, can also help the user to generate insights to improve the analysis framework as well as the coding support component for conducting further content and participation analyses.

Coding Support Component

The coding support component supports researchers to conduct content analysis in more efficient ways through text mining of the discourse. As an intelligent tool, after the user has selected the coding scheme(s) to conduct coding, it should be able to provide aids, like highlighting discourse segments that match with the text patterns in the coding rules database and suggest appropriate codes for those segments. Since it is envisaged that there are limitations to the effectiveness of automatic coding based on the coding rules alone, the user will be able to decide which of the coding suggestions to accept. The coding hits and coding errors will be recorded. Further, the user may identify missed segments which should have been coded and add these codes in manually. These coding misses will also be recorded. After the coding process has been completed, the coded segments and the coding statistics (i.e. the frequency of occurrence of the various codes) will be generated for the user. This output can be exported in a database format for further quantitative and code co-location explorations. In addition, there are two more outputs from this process, the coding effectiveness statistics for each set of coding rules fired and three lists of discourse segments for the coding hits, coding errors and coding misses respectively in database format. These last two sets of outputs will be further processed by the learning mechanisms component. This is the core content analysis component in this suite of assessment tools and it is also potentially the most powerful one since it is improvable with increased use through the learning mechanisms component included in this toolkit. When the coding effectiveness of the coding rules improves, this component can be further developed to provide a training module for new coders. The coding results for the same set of discourse data by different coders can also be compared using this component to provide inter-coder reliability statistics as well.

An index of the coded discourse segments can also be fed back to the segmented discourse database to support further text selection criteria to allow more focused multi-step analysis of the CSCL discourse such as participation and interaction analysis for discourse having specific characteristics.

Learning Mechanisms Component

There are two modules in this component designed to refine and improve on the coding scheme and the coding rules database that form the knowledge base for the coding support component. One module is the coding rules refinement module which makes use of the hits, mistakes and misses lists of discourse segments and the coding effectiveness statistics for the rules associated with each code generated by the coding support component to improve on the coding rules. The second is the coding scheme and rules modification module which takes as its input the text analysis output and the user's instructions on the kinds of modifications desired. This module should be able to interpret keywords, keywords concordancing results, and results from domain ontology analysis.

Example Content Analyses Using VINCA, a Toolkit Prototype

The Visual INtelligent Content Analyzer (VINCA) is a CSCL discourse assessment tool jointly developed by the Centre for Information Technology in Education of the University of Hong Kong and the Knowledge Science and Engineering Institute of the Beijing Normal University to implement the design ideas described above. To date, a prototype for some of the preparatory components and the text analysis components have been implemented while the participation analysis and learning mechanism component has still to be developed (Huang & Li, 2006). This prototype is able to process textual records of discussion in both English and Chinese. In this section, we will give an example of how the text analysis component provides content analysis support that help to locate indicators of learning, irrespective of theoretical underpinnings, from online discussion logs. It is our intention that findings generated by the text analysis components will become one important source of information about students' learning that can be integrated with the participation analysis component to provide useful information to the teacher as well as learners about the progress of the discussion (Mochizuki et al. (2005) reported on an interesting study in which students' learning and interactions were influenced by the visualization of the proximity of their contribution to set keywords entered by the teacher).

Two groups matched in academic ability participated in an online knowledge building (Scardamalia & Bereiter, 2003) activity on the topic of "slimming" using Knowledge Forum® organized as part of their formal school curriculum. Three instruments were designed and administered to the two groups of students after they have completed the online activity to assess the impact of the activity on them. The three instruments were a weight-loss and nutrition concept test, a daily food intake inventory, and a weight-loss, exercise and body-image survey. It was found that the learning activity had significant impact on the understanding and attitudes on the students in one of the two groups (group A) but not on the other (group B) as measured by both the weight-loss and nutrition concept test scores and the self-image scores. However, group A had lower counts than group B on some commonly used quantitative indicators of discourse engagement: the total number of notes posted, the total number of threads, the length of entries and the total number of keywords in the messages recorded on Knowledge Forum®. VINCA was employed to see if it can provide some useful information on why such an outcome might come about. In particular, VINCA was used find out whether the two groups differed in the quality of the online learning discourse. The analysis provided evidence that group A in fact had a different engagement pattern to group B in the online discourse. This study was briefly reported in Law & the Learning Community Project Team (2006). Due to the limitation of space, only one of the analyses done using VINCA is reported below as an illustration of how this tool can be used to identify different levels of engagement. Detailed reporting on the whole study will be the subject of another paper.

To identify indicators of learning through the online discussion, VINCA's text analysis component started with retrieving all keywords and their counts from the whole discourse of the two groups of students. The aim is to identify keywords that may be indicative of students' cognitive and/or metacognitive engagement. From the keywords retrieved, three groups were identified to be useful as indicators of deep engagement that will likely lead to deep learning. One such group of keywords was indicative of *reflection* such as consider, think, know, believe, feel and agree (1). The second group was indicative of the author making a *claim* or a proposition, and included words such as in fact, therefore, moreover, explain and based on. A third group was words indicative of the author making a *query*, such as what, why, how and words used in questions. Table 2 presents the density of use of these 3 types of keywords in these two groups' discourses. It is apparent from the density of use of these 3 types of keywords that more cognitive engagement were present in group A's online discourse.

While the keywords were useful, it was also found that statements containing specific keywords per se may not actually be related to reflections, propositions or queries. Upon closer inspection, statements containing the personal pronoun "I" in the proximity of these three types of keywords were more likely to be statements that involved reflections, claims or queries. In order to increase validity in identifying indicators of learning from online discussion discourse, a two step identification process was designed. Firstly, concordance segments of text containing 20 words before and after the word "I" was extracted by the data preparation component in VINCA. These data subsets were then analyzed by the keywords analyzer in the text analysis component. The density of use of the 3 identified types of keywords in this selected set of text is also presented in Table 2. The result shows that group A again has a higher density in the use of these 3 types of keywords. Furthermore, the density difference between these two groups is even higher in this subset of text segments containing the personal pronoun "I".

To summarize, using the keywords analysis and text concordance analysis modules in VINCA, we have found quantitative difference in the density of keywords associated with deeper cognitive and metacognitive engagement identified through a two-step process between the two groups of students which suggested that group A was more engaged in the online discourse. This triangulates well with the finding that group A achieved better learning outcomes based on the weight-loss and nutrition concept test and self body-image survey. These results demonstrate that VINCA is potentially useful in providing useful indicators of learning engagement beyond simple quantitative measures of writing engagement such as the total number of keywords or word counts. We hope these would contribute to further discussions and developments in analyzing CSCL discourse.

Table 2 A comparison of the word count and word density for the three selected groups of keywords indicating reflection, explanation and query posted by the two groups of students in (a) the whole discourse, and (b) the concordanced text segments containing the personal pronoun "I",

		Word Count & word density for selected keywords in the whole discourse				Word Count & word density for selected keywords in the concordanced text segments containing "I"			
		Group A		Group B		Group A		Group B	
	Number of keywords identified	1552		5396		738		2758	
	Total number of occurrence for all keywords identified	4824		26546		1834		9986	
	Keywords	Number of occurrence	Density per 1000 keywords occurrence	Number of occurrence	Density per 1000 keywords occurrence	Number of occurrence	Density per 1000 keywords occurrence	Number of occurrence	Density per 1000 keywords occurrence
Reflection	認爲 Consider	19	*3.94*	34	*1.28*	15	*8.18*	10	*1.00*
	想 Think	5	*1.04*	27	*1.02*	4	*2.18*	19	*1.90*
	覺得 Feel	8	*1.66*	11	*0.41*	6	*3.27*	4	*0.40*
	相信 Believe	2	*0.41*	7	*0.26*	1	*0.55*	3	*0.30*
	知道 Know	2	*0.41*	7	*0.26*	2	*1.09*	2	*0.20*
	感到 Sense	2	*0.41*	7	*0.26*	2	*1.09*	2	*0.20*
	認同 Agree	4	*0.83*	1	*0.04*	3	*1.64*	1	*0.10*
	Category Total	**42**	***8.71***	**94**	***3.54***	**33**	***17.99***	**41**	***4.11***
	Density Diff.	***8.71-3.54 = 5.17***				***17.99-4.11 = 13.88***			
Claims	其實 In fact	15	*3.11*	17	*0.64*	9	*4.91*	9	*0.90*
	所以 Therefore	6	*1.24*	33	*1.24*	3	*1.64*	17	*1.70*
	而 Besides	18	*3.73*	96	*3.62*	13	*7.09*	43	*4.31*
	而且 Moreover	5	*1.04*	16	*0.60*	3	*1.64*	10	*1.00*
	解釋 Explain	1	*0.21*	1	*0.04*	0	*0.00*	1	*0.10*
	根據 Based on	4	*0.83*	10	*0.38*	1	*0.55*	2	*0.20*
	Category Total	**49**	***10.16***	**173**	***6.52***	**29**	***15.81***	**82**	***8.21***
	Density Diff.	***10.16-6.52 = 3.64***				***15.81-8.21 = 7.6***			
Queries	甚麼 What	5	*1.04*	0	*0.00*	3	*1.64*	0	*0.00*
	爲甚麼 Why	2	*0.41*	0	*0.00*	2	*1.09*	0	*0.00*
	怎樣 How	3	*0.62*	2	*0.08*	1	*0.55*	0	*0.00*
	如何 How to	1	*0.21*	7	*0.26*	0	*0.00*	4	*0.40*
	嗎 Question indicator	9	*1.87*	9	*0.34*	3	*1.64*	3	*0.30*
	呢 Question indicator	10	*2.07*	6	*0.23*	7	*3.82*	5	*0.50*
	Category Total	**30**	***6.22***	**24**	***0.90***	**16**	***8.72***	**12**	***1.20***
	Density Diff.	***6.22-0.9 = 5.32***				***8.72-1.2 = 7.52***			

Conclusion

In this paper, we have put forward a framework for categorizing methods used by CSCL researchers to analyze online discourse to assess students' learning outcomes and processes. Specifically, three types of outcomes (cognitive, metacognitive and socio-metacognitive) and six types of processes (participative, social, interactive, cognitive, metacognitive and socio-metacognitive) were identified. A proposal that this categorization together with the unit of analysis adopted should form a basic nomenclature for use by CSCL researchers in reporting on the assessment methodologies they use in analyzing CSCL discourse to facilitate easier methodological comparison and explorations. A conceptual design for a suite of learnable CSCL assessment tools that makes use of such a nomenclature is also presented. This proposed toolkit contains three analysis components, a participation and interaction analysis component, a text analysis component and a coding support component which will provide quantitative participation and interaction statistics, make intelligent coding suggestions for content analysis as well as iterative multi-method analysis. A very attractive feature of this set of tools is the availability of a coding schemes and coding rule database which forms the knowledge base for the content analysis components. The learnability is accomplished through the learning mechanisms component which contains modules that can modify and improve on the coding schemes and coding rules contained in the database. The learning mechanisms component contains a coding rules refinement module that can make improvements to the coding rules on the basis of the coding effectiveness of the coding support mechanism and a coding scheme and rules modification module which can make improvements on existing coding schemes and rules on the basis of the text analysis output. An example of how VINCA, a prototype developed on the basis of this conceptual design, helped to compare the levels of cognitive engagement for the online discourse from two groups matched in academic ability was also provided to illustrate the viability and usefulness of such assessment tools to generate analytical insights irrespective of the learning theory underpinning the CSCL design. It is expected that when the full suite of tools has been developed such that content analysis results can be analyzed and interpreted together with the results from participation and interaction analysis, we will be able to gain a much better understanding of what distinguishes a productive CSCL discourse and how that can be fostered. It will also contribute towards theory building about CSCL. as well as cont the suite to support mixed-method evaluation for evaluating different levels of engagement in CSCL based on the framework suggested. It is hoped that more researchers will be interested in developing and sharing assessment tools based on this conceptual design. This will facilitate collaboration and critical co-construction of knowledge about CSCL among researchers and improve our understanding of the outcomes and processes of online collaborative learning.

Endnotes

(1) The actual text written by the students were mostly in Chinese. The words listed here are just translations.

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