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Exploring Individual and Collaborative Dimensions of Knowledge Building in an Online Learning Community of Practice

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Abstract. An exploratory study of students' engagement in online learning and knowledge building is presented in this paper. Learning in an online community, composed of students (pre-service teachers) and experts (experienced in-service schoolteachers and academics), is the study's primary focus. Students' interaction and knowledge discourse structures, arising from individual readings of academic papers and asynchronous collaboration with peers and experts, are investigated using social network and content analysis techniques. Additionally, several new measures for exploring structural-qualitative aspects of knowledge discourse are introduced. Analysis revealed several important trends. First, students' interaction was more intensive in forums where experienced teachers participated, rather than students only. Second, students' individual discourse structures in their postings were quite deep, knowledge-focussed and elaborated; while students' replies were short, usually focussed on specific idea and contained a substantial amount of non-cognitive information. Overall, it is argued that students were engaged with the individual and collaborative knowledge building in the online learning community. Practical implications of the study results for development of courses are discussed.

Keywords: pre-service teachers' education, online learning communities, communities of practice, computer-supported collaborative learning, asynchronous communication, cognitive presence, social network analysis, content analysis.

Introduction

The capability to systematically learn and reflect on practice is critical for specialists engaged in complex professional activities (Schön, 1983). In practice-based professional domains, such as teaching, expert knowledge is a complex nexus between theoretical knowledge and practical experience (Ebbutt *et al.*, 2000; Little, 2003). This knowledge could be acquired through simultaneous engagement with, and reflection on, theoretical knowledge and practical experience, combined with active involvement in an individual and collaborative knowledge building. Traditional university environments primarily expose students to theoretical academic discourses, while engaging them in individual knowledge building. Computer-supported collaborative learning environments provide the possibility to connect students to external professional enterprises and society at large,

and to create new communal knowledge-creation structures, such as online learning communities of practice (Bruckman, 2006). A *community of practice* model provides opportunities for students, as future professionals, to engage simultaneously in individual and collaborative knowledge creation, integrating theoretical academic knowledge with practical expert discourses (Wenger, 1998).

Research on knowledge-building through individual engagement with content and collaboration in learning communities is limited to a small number of typically small-scale case studies (Johnson, 2001; Wallace, 2003). This paper explores individual and collaborative knowledge building in a large postgraduate pre-service teacher education course using social network and content analysis methodologies. Several new measures for studying social and cognitive engagement and structures of students' online discourses are introduced.

The paper is structured into five sections. The first section provides an overview of key pedagogical rationales and their relevance to pre-service teacher education. The next section describes the context of the study and research questions. The third section presents methodological approach and introduces new measures for structural-qualitative analysis of knowledge discourse. The fourth section presents results of the study. The final section explores key findings and presents conclusions. It also discusses the limitations and usefulness of the new content analysis measures for the investigation of students' knowledge discourses in large-scale studies.

1. Active Knowledge Building and Community of Practice Model

1.1. *Active Learning: Individual and Collaborative Aspects of Knowledge Building*

Theories and instructional principles of active knowledge building (Greeno, 2006) trace their roots to socio-constructivist and socio-cultural approaches to learning. Research conducted during the last three decades substantiates, learning and comprehension are an active process of knowledge building rather passive information reception (Chan *et al.*, 1992; Lucangeli *et al.*, 1997; Scardamalia and Bereiter, 1987). Knowledge building is situated in social context and higher level critical thinking within individual develops in a "community of enquiry" (Lipman, 1991). Three different modes of interaction are important in this knowledge-building process: (a) student to teacher, (b) student to student and (c) student to content (Anderson, 2003). Therefore, effective pedagogical designs should integrate individual cognitive and interactive group-based components, combining active individual engagement with the content and collaborative knowledge co-construction.

1.2. *Pre-service Teachers' Education, Asynchronous Online Discussions and Learning Communities of Practice*

The relevance of group-based constructivist learning methods to adult experience (Huang, 2002) and widespread adoption of computer networks brought forth a new learning model – online learning communities (Wallace, 2003). Learning communities are collaborative

communities of learners, who work together to support everyone's learning (Bruckman, 2006). The learning community model provides an opportunity to introduce new learning methods, enhancing prospective teachers' critical thinking, into pre-service education.

Effective teaching depends on a mixture of theoretical understanding and practical knowledge (Meijer *et al.*, 2002; Shulman, 1998). However, prospective teachers often perceive theoretical principles, developed through formal education, as disconnected from their future teaching practice (Shulman, 1998). Reflective processes have been shown to support interconnections of theoretical and practical knowledge (Dewey, 1933; Geddis *et al.*, 1998; Pultorak, 1993). However, numerous studies have shown, prospective teachers find reflective capacities difficult to acquire (e.g., Gale and Jackson, 1997; Hatton and Smith, 1995).

Hmelo–Silver (2003) argues, computer-supported collaborative learning environments are cultural artefacts, and a critical psychological tool regulating learners' thinking and interactions. Asynchronous computer conferencing, as a text-based environment, offers several important pedagogical features supporting reflective learning. Davis and Brewer (1997) argue, asynchronous environments may support reflection by providing additional time for thinking. Further, Flynn and Polin (2003) assert, writing in asynchronous communication environment is a dialogue between several people and a dialogue with oneself. Written conversation in an asynchronous environment is a reflective process and a basis for joint knowledge building. Augmenting this statement, Garrison, Anderson and Archer (2000) argue, "it is reflective and explicit nature of the written word that encourages discipline and rigor in our thinking and communicating. In fact, the use of writing may be crucial when the objective is to facilitate thinking about complex issues and deep, meaningful learning" (p. 90). Finally, research shows (Lin *et al.*, 1999; Suthers, 1998), computer-supported learning environments can provide different technological scaffolds, mediating reflection and shared knowledge building.

Computer networks provide an opportunity to introduce alternative methods of professional knowledge development into pre-service teachers' education – to create learning communities of professional practice (Sutherland *et al.*, 2005; Sutherland *et al.*, submitted). These are special types of online learning communities (Bruckman, 2006) and communities of practice (Johnson, 2001; Wenger, 1998) which provide pre-service teachers (students) opportunities to engage with experts (in-service schoolteachers and university academics), focusing on the acquisition of professional knowledge. In such communities, students, schoolteachers and academics engage in on-going online and face-to-face opportunities to share their experience and enhance their professional knowledge. Groups study theoretical principles and discuss implications of these principles on the daily work of schoolteachers.

Written asynchronous conversation between students and experts is the main activity in the online learning community. The computer-supported learning environment allows participants to externalise their thinking through writing (e.g., make statements, elaborate, reflect) and create written knowledge discourse. Using Bereiter's (2002) concepts of "knowledge-building" and "conceptual artefacts" and Collins's and Ferguson's (1993) "epistemic forms", this written discourse can be classified as a textual representation of

collaboratively created "conceptual artefacts" – knowledge structures that represent distinctive way of thinking and acting in a particular epistemic community (Goodyear and Zenios, 2007). Captured in an online learning environment, collaboratively constructed texts provide an important source of data for investigating knowledge building processes in an online community.

2. Study Context and Research Questions

2.1. *Pedagogical and Technological Design of the Online Learning Community*

The research took place over 12-week period within a postgraduate pre-service course "Introduction to teaching and learning". The course is a core requirement within a two-year Master of Teaching program offering a comprehensive introduction to the issues of teaching and learning, curriculum and the social and institutional context of education. The Master of Teaching is a special two-year program, designed for students who have completed a bachelor's degree in any area (e.g., engineering, arts) and would like to obtain a teaching qualification.

The course design is underpinned by the notion of the teacher as critically reflective practitioner (Brookfield, 1995). The course includes several components: (a) lectures; (b) face-to-face seminar sessions; (c) observation visits to schools; (d) maintaining an individual learning journal; (e) independently reading academic papers and (f) discussing readings in an online learning community of practice. The last two components in the first semester are supported by an asynchronous online learning environment and are investigated in this study.

The course was comprised of pre-service teachers (students) and experts (in-service schoolteachers and university academics). Students were allocated into small reading groups (4–5 students per one reading group) and all reading groups were divided into larger seminar groups (5 reading groups per one seminar group). One in-service teacher from a secondary or primary school and one university academic were assigned to each seminar group. Students were provided with a set of compulsory readings (1–2 academic papers per week) related to the weekly lecture and face-to-face seminar topics. Students were expected to complete weekly readings and post a 300-word reflective summary into their reading group discussion forum at least four days before face-to-face seminar. In the summary students were asked to identify three significant points in their readings and explain why these points were important to them. After a short online discussion, one member of each reading group summarised all views and posted a joint group summary with questions to the assigned schoolteacher, into the seminar discussion forum. Schoolteachers responded to students' messages by answering questions and providing experience-based opinions related to students' insights. Students, schoolteachers and academics were free to contribute to this seminar discussion: reply, ask questions or provide additional insights, as often as necessary. Later, the key issues from the weekly readings and online discussions were discussed in a weekly face-to-face seminar session led by a university academic.

The online learning environment was developed using an open-source content management system, "Plone". Before posting messages to the online forums, participants were asked to structure messages into paragraphs using one of seven pre-specified knowledge labels (Table 1). Knowledge labels aimed to support professional knowledge-building and were aligned with online learning aims and pedagogical design. They articulated the process of individual critical thinking, reflection and group argumentation. In order to allow free conversation and social presence to develop, participants were permitted to attach the "No-knowledge" tag or not label the message at all (i.e., "Default label"). The labels' semantic meaning was described for students in the course readings (resource book).

Table 1

Knowledge labels, stages of cognitive presence, coding categories, weights and examples

Knowledge labels	Phases of cognitive presence$^{\alpha}$	Coding category (weight)	Examples
Request – asking a question. ***Explanation*** – statement about your understanding.	*Triggering event* – sense of puzzlement, recognizing the problem.	Proposing (1)	"I believe the main aim of the text was to inform the readers of the various conflicting views held by the different constructivist sects. The author tries to draw similarities between the difference sects by showing how they are really all the same (in a way) just at diffe rent ends of a continuum. Thus they are all link, to some degree, no matter how vastly apart they may seem."
Supporting argument – agreement with someone's idea. ***Counterargument*** – disagreement with someone's idea.	*Exploration* – divergence, information exchange, suggestions, brainstorming.	Investigating (2)	"Thanks for your argument that the fear that popular culture might pressure teachers to put on a facade seems to be a little extreme. I believe that as a society we cannot underestimate the power of popular culture. I think the messages we all receive daily about how to live (TV sitcoms or soaps), what is the ideal relationship (The Brady Bunch etc) or even what to believe in (Hollywood meets political agendas), are subversive and very influential. I agree that knowingly I would like to think I could not be influenced ... but I believe unconsciously we all are."
Elaboration – provision of additional evidence or insights.	*Integration* – convergence, connecting ideas and creating solutions.	Elaborating (3)	"Cuban has shown in his article the gradual shift from teacher-centred to student-centred instruction as the century progressed and the contributing factors that determine classroom practices. It would be of interest to study the type of conditions that influence how students are being taught today and compare it with the conditions of the last century. Surely, our current social beliefs and scientific knowledge have as much influence on our teachers and administrators as it did a century ago. Both Vygotsky and Piagethas been often mentioned in lectures this week, their theories seem to be very influential in our current view of children's learning, what are other influential theories or social beliefs that impact on teaching instruction?"

Knowledge labels	Phases of cognitive presence[α]	Coding category (weight)	Examples
Application – discussing how an idea could be used in addressing an issue. ***Reflection*** – discussing how an idea helps you to understand an experience or changes your beliefs.	*Resolution* – vicarious application, testing and defending solutions.	Reflecting (4)	"I believe the practices of pedagogy that were outlined in this article, in relation to students that come from a secondary Discourse background, were evident in many of the schools we visited. I was witness to teachers ignoring and wrong or inappropriate answers and reverting to dictating right answers in order to 'keep the kids on track' and to basically 'put their own words in the students mouths' (p. 27)."
No-knowledge – social information, maintenance, off-task comments.	NA	No-knowledge (0)	"My apologies for spelling your name wrong... I must be over tired." "That's all from me... hope this helps."
Default – a message is not labelled.	NA	Default label (NA)	

Note. [α] Based on Garrison *et al.* (2001).

2.2. *Research Questions and Assumptions*

This study aims to explore how, within an online learning community of practice, students engaged in the learning process and constructed their professional knowledge through individual and collaborative discourses.The main research questions addressed in this study are the following:

1. What levels of interaction occurred between (a) the student and the content, (b) student and student, and (c) student and expert (schoolteacher)?
2. To what extent students' knowledge discourse structures, arising from interaction with content (weekly readings), as shown in their postings, differ from discourse structures arising from interactions with other group members, as shown in replies.
3. What impact does the online environment organisation have on interaction levels and discourse structures in the different discussion forums (reading and seminar groups)?
4. Did students value their online learning experience, and does their opinion about online learning relate to their engagement in online learning.

Analysis was based on the assumption, pedagogical design of the online learning and knowledge labels supported two kinds of interaction and three kinds of students' knowledge discourses. Types of interaction included: (a) discussions among students

within small reading groups and (b) discussions among students, schoolteachers, and academics within large seminar groups. Types of student knowledge discourse included: (a) information structures emerging from student to content interactions (expressed in students' postings and discourses emerged from weekly readings); (b) information structures emerging from student to student interactions, (expressed in students' replies in small reading groups); and (c) information structures emerging from student to teacher interactions (expressed in students' replies in large seminar discussions with schoolteachers and university academics).

3. Method

3.1. *Analytical Approach*

Following Greeno's (2006) perspectives on situative learning and Herring's (2004) methodological approach, analysis included two aspects: (a) interaction patterns that included analysis of online discussion structural-interaction features, and (b) content that included analysis of structural-qualitative aspects of the postings and replies.

The structural-interaction features relate to physical dimensions of network and information exchanges. They were examined in terms of main network and participation parameters: network size (number of participants); intensity (numbers of postings and replies, averages per participant) and interactivity (messages with replies) (Fahy, 2001; Fahy *et al.*, 2001; Jeong, 2005).

The structural-qualitative aspects relate to the content of participants' contributions. Contributions were examined using theory-driven discourse and content analysis techniques (Cook and Ralston, 2003; Herring, 2004; Mazur, 2004; Rourke *et al.*, 2001). Garrison's *et al.* (2001) "cognitive presence" taxonomy was used as a generic framework for studying information structures of the students' online contributions. Cognitive presence is "the extent to which the participants are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry" (Garrison *et al.*, 2001, p. 5). According to Garrison *et al.* (2001), cognitive presence includes four hierarchical stages: (a) "Triggering event"; (b) "Exploration"; (c) "Integration" and (d) "Resolution". Stages reflect the quality and extent of deep and meaningful knowledge building. On the basis of the semantic similarities between the descriptions of the knowledge labels, which were used by participants in the online forums, and the stages of cognitive presence, the knowledge labels were mapped to the four broader phases of cognitive presence (Table 1). Four corresponding knowledge categories, reflecting stages of cognitive engagement, and two additional coding categories for "No-knowledge" paragraphs and unlabelled messages (Default) were created and used in the analysis. Reliability of students' self-coding and mapping were assessed by research assistants (see Section 3.2).

Semantic units of meaning were paragraphs identified by students. Students' messages typically comprised more than one paragraph, thus labels from the same category may occur multiple times in a message. In order to avoid the impact of the text structure

on research results, units of meaning were combined into two larger hierarchical units of analysis: (a) coding categories, weighted by a number of words, and (b) messages. Each category was characterised by its length (number of words). Each message was characterised by (a) length and (b) presence or absence of various categories. To investigate the students' engagement in individual and collaborative knowledge building, the following parameters were examined: (a) average number of categories per message; (b) frequencies of occurrence of all categories in the messages; (c) indexes of engagement; and (d) relative category collocation matrixes. The latter two measures are described below.

3.2. *Structural-Qualitative Measures of Knowledge Discourse: Indexes of Engagement and Category Collocations*

Three indexes were introduced to get summarised information about students' cognitive and social engagement in online learning (Markauskaite *et al.*, 2006).

Index of Cognitive Engagement:

$$\text{ICE} = \sum_{i=1}^{4} i \cdot l_i \Big/ \sum_{i=1}^{4} l_i.$$

Index of Social-Cognitive Engagement:

$$ISCE = \sum_{i=0}^{4} i \cdot l_i \Big/ \sum_{i=0}^{4} l_i.$$

Index of Social Engagement:

$$ISE = l_o \Big/ \sum_{i=0}^{4} l_i,$$

where i are ordinal weights assigned to each stage of the cognitive engagement (i.e., 0 – "No-knowledge" and from 1 – "Proposing" to 4 – "Reflecting") and l_i is the length (words) of the paragraph with a code i.

The ICE and ISCE characterise the average cognitive level of the message. They are calculated by multiplying the length of the paragraphs in each category by its cognitive weight, and normalising by total message length. The ICE is based on the knowledge categories only (i.e., from "Proposing" to "Reflecting") and could acquire values from 1 (only propositions) to 4 (only reflections). In contrast, ISCE takes into account presence of "No-knowledge" labels. Thus, ISCE could range from 0 (only no knowledge) to 4 (only reflections). The ISE indicates the relative amount of no knowledge information in a message (e.g., greetings, off-task comments). ISE is calculated by dividing the length of "No-knowledge" paragraphs by the length of the message and could range from 0 to 1. Thus, ISE equal to 0 would indicate that only knowledge labels (i.e., from "Proposing" to "Reflecting") were used in the message, while equal to 1 would indicate only "No-knowledge" label was used.

To examine the structure of students' discourse in the messages, a Relative Collocation Matrix (RCM) was introduced:

$$c_{ij} = \frac{freq(i,j)}{freq(j)}, \quad i \neq j; \qquad c_{ii} = \frac{freq\big(i \big| l_i = \sum_{j=0}^{4} l_j\big)}{freq(i)},$$

where l_i and l_j – the length (words) of category i and category j in the message.

RCM shows the collocation of knowledge categories in the messages. RCM is an asymmetric measure. Each non-diagonal cell c_{ij} ($i, j = 0 \ldots 4$; $i \neq j$) represents the *frequency of the co-occurrence* of the label from the category i and category j in relation to all occurrences of category j in the messages. Each diagonal cell c_{ii} ($i = 0 \ldots 4$) represents *the singularity* of the category, which is the frequency of the occurrence of a category i in the messages solo (i.e., all text in the message belongs to category i) in relation to all occurrences of category i (i.e., solo or collocated with other categories j, where $i \neq j$). For example, the text from a message that includes one or several paragraphs with attached labels from the one category only (e.g., "Elaborating") will belong to c_{ii} (i.e., c_{33} in the latter example). Whereas, the text from a message that includes several paragraphs with attached labels from more than one category (e.g., "Proposing" and "Elaborating") will belong to c_{ij}, $i \neq j$ (i.e., c_{13} and c_{31} in the latter example).

Therefore, each column j is a vector showing proportion of all category j occurrences as it co-occurs with category i or alone. It could be interpreted as a *conditional probability* of category i given occurrence of category j. The sum of non-diagonal values in column j ($CC_j = \sum_{i=0, i\neq j}^{4} c_{ij}$) indicates the total *Co-occurrence Capacity* (CC) of category j. This indicator ranges from 0 to 4, showing with how many other categories, on average, category j co-occurs (i.e., 0 – category j occurs solo in all messages, 4 – category j co-occurs together with all other four possible categories). For example, if all "No knowledge" labels ($j = 0$) were used in the messages only alone, then $c_{00} = 1$, $c_{i0} = 0$ ($i = 1 \ldots 4$) and consequently $CC_{00} = 0$. In an opposite extreme situation, if "No knowledge" label was used in all messages in conjunction with all knowledge categories ($i = 1 \ldots 4$) and never were used solo, then $c_{00} = 0$, $c_{i0} = 1$ ($i = 1 \ldots 4$) and consequently $CC_{00} = 4$.

3.3. *Data, Materials and Participants*

Two data sources were used: (a) automatically collected online data and (b) the course evaluation questionnaire. Automatically collected online data included all participant online contributions into reading and seminar group forums during the 12-week term. After the end of the semester, content of all contributions together with descriptive identifiers (i.e., author; message identifier; parent message identifier, if reply posts; time and discussion group identifier) were exported into a database. Labels, attached by participants to paragraphs, were recoded with the new six-category coding scheme (Table 1).

The course evaluation questionnaire examined students' online learning experience, and other aspects of the course. Four multiple-choice items, relevant to the aims of this study, were analysed.

Participants were 226 students. They were allocated into 45 small reading groups and all reading groups were allocated into nine seminar groups. One schoolteacher and one university academic were assigned to each seminar group. During the last week of the semester 89 (39.4%) volunteer students completed the survey. 87 students answered the questions about their online learning experience.

3.4. *Reliability*

The reliability of participants' self-coding was assessed externally on a random 201 message sample (Markauskaite *et al.*, 2006). A research assistant checked participants' labelling using the six-category coding scheme and indicating agreement or disagreement with the student assigned code. In uncertain cases, the research assistant consulted investigators before making a final decision. Each paragraph (i.e., initial unit of meaning) was weighted by a number of words; and Hosti's percent of agreement (cr) and Cohen's kappa (k) on a weighted sample were calculated. The results indicated that students' self-coding in reading groups ($k = 0.62$, $cr = 75.0\%$) and seminar groups ($k = 0.63$, $cr = 72.9\%$) were sufficiently reliable (Rourke *et al.*, 2001).

4. Results

4.1. *Structural-Interaction Features of the Online Discussions*

Size. The network consisted of 239 participants: 226 students, 9 schoolteachers and 4 university academics (i.e., 2 lecturers, who led face-to-face tutorials in 3 seminar groups, never participated in online discussions).

Intensity. In total 4801 messages were posted: 4245 (88%) by students and 556 (12%) by schoolteachers and academics. On average each participating student posted 18.78 ($SD = 9.04$) messages: 14.00 ($SD = 6.58$) messages were posted in reading group discussion forums and 5.03 ($SD = 3.28$) messages in seminar group discussion forums (Table 2). Original postings (not including replies) accounted for more than two thirds of all students' contributions in both discussion forums. In reading groups, the average number of postings was 11.09 ($SD = 3.52$) per student, almost equal to the required minimum (11 postings). In seminar discussion forums, the average numbers of postings was 3.42 ($SD = 3.28$), which was higher than the required minimum (2 postings).

Interactivity. 3499 (73%) of all contributions were postings and 1302 (27%) were replies. Overall, the discussions were more interactive in seminar groups than in reading groups, and replies amounted to 40% and 21% respectively. In seminar forums however, about 44% of the replies were posted by schoolteachers and academics and only 56% by students. Nevertheless, the average reply to posting ratio for students only was also significantly higher in the seminar group discussions ($M = 0.46$, $SD = 0.61$) than in the reading group discussions ($M = 0.24$, $SD = 0.29$), $t(217) = 5.665$, $p < .001$, $d = 0.36$. This indicated that students were more interactive in the latter forums.

Table 2

Structural indicators of the students' messages

Forums and types of the messages	Messages		Length of message		Labels per message		Participants	Mess. per participant		Total length per participant	
	n	%	Words	SD	M	SD	n	M	SD	Words	SD
Reading groups	3139	73.9	311	213	1.94	1.06	224	14.01	6.58	4357	1940
– postings	2485	58.5	370	194	2.10	1.09	224	11.09	3.52	4101	1756
– replies	654	15.4	88	103	1.33	0.67	170	3.85	4.43	337	500
Seminar groups	1106	26.1	293	253	1.82	1.06	220	5.03	3.28	1475	923
– postings	753	17.7	390	247	2.03	1.14	220	3.42	1.51	1335	805
– replies	353	8.3	87	94	1.34	0.68	129	2.74	2.42	239	323
Total	4245	100	306	224	1.91	1.06	226	18.78	9.04	5755	2618

Note. Table presents students' messages only.

4.2. *Structural-Content Features of the Students' Contributions*

The total volume of all participants' contributions was more than 1.485 million words. On average each student contributed 5755 ($SD = 2618$) words (Table 2). About 88% of the volume were postings, 12% were replies. About 69% of text volume were posted in the reading group and 31% in the seminar group forums.

The average students' posting length in reading and seminar group forums was 370 ($SD = 194$) and 390 ($SD = 247$) words, respectively; whereas replies were more than four times shorter than the postings: 88 ($SD = 103$) and 87 ($SD = 94$) words respectively, Welch $F(3, 1354) = 1202.66$, $p < .001$. Games–Howell contrasts revealed, postings were significantly longer than replies within the reading and seminar group forums ($p < .001$); whereas the differences between the forums were insignificant ($p > .05$), i.e., length of posts and replies in reading group forums were similar to lengths of posts and replies in seminar group forums, respectively.

On average, labels applied in students' messages belonged to 1.91 ($SD = 1.06$) different categories. On average, labels from more than two categories were attached to students' postings in reading ($M = 2.1$, $SD = 1.09$) and seminar ($M = 2.0$, $SD = 1.14$) forums, whereas labels from less than 1.5 different categories were attached to replies in both forums ($M = 1.3$, $SD = 0.67$ and $M = 1.4$, $SD = 0.68$, respectively), Welch $F(3, 1268) = 225.25$, $p < .001$. Games–Howell contrasts revealed, on average, postings were labelled from significantly more categories than replies in the reading and seminar group forums ($p < .001$). Differences between the forums were insignificant ($p > .05$), i.e., the average number of categories used in the postings and replies in the reading group forums were the same as the number of categories used in the postings and replies in the seminar group forums.

The dominant knowledge category in students' postings was "Proposing" (Table 3). The labels from this category (i.e., "Request" and "Explanation") were used in about two thirds of reading and seminar discussion postings. "Reflecting" was the second most

Table 3

Students' usage of different labels in reading and seminar group messages

Discussion forum		Proposing		Investigating		Elaborating		Reflecting		No-knowledge		Default label		Total	
		P	R	P	R	P	R	P^{**}	R	P	R^{**}	P	R^{**}	P	R
Reading groups	n	1669	137	531	100	719	53	1214	109	811	272	270	196	2485	654
	%	67.2	20.9	21.4	15.3	28.9	8.1	48.9	16.7	32.6	41.6	10.9	30.0	100.0	100.0
Seminar groups	n	488	82	153	39	225	31	320	77	253	178	93	77	753	353
	%	64.8	23.2	20.3	11.0	29.9	8.8	42.5	21.8	33.6	50.4	12.4	21.8	100.0	100.0

Note. P – postings; R – replies; n – the number of the messages with the occurrence of a label; χ^2 – between reading and seminar groups: $^{*} - p < .05$; $^{**} - p < .01$; $^{***} - p < .001$.

frequently applied category. The labels from this category (i.e., "Application" and "Reflection") were used in less than half of student posts. The labels from "Investigating" (i.e., "Supporting argument" and "Counterargument") and "Elaborating" (i.e., "Elaboration") categories were used in approximately one-quarter of the postings. About one third of the postings contained some text, labelled "No-knowledge" (i.e., greetings, social comments). "Reflecting" labels were used more frequently in reading group posts (49%) than seminar group (43%) postings, $\chi^2(1, N = 3238) = 9.37$, $p < .01$; labels from all other categories were used equally in both forums ($p > .05$).

In replies, students most often used "No-knowledge" label or chose not to label their messages and left "Default label." "Proposing" and "Reflecting" were the dominant knowledge categories, used in 17%–23% of the students' replies. The labels from all four knowledge categories were significantly ($p < .001$) more often used in postings than in replies.

Tho get summarised information about structural-content features of students' contributions, social and cognitive engagement indexes were calculated (Table 4). As it is impossible to attach ordinal value to non-labelled category ("Default label"), these indexes were calculated for labelled messages only. The average ICEs were between 2.1 and 2.5, indicating a moderate level of students' cognitive engagement in individual and collaborative knowledge building. The average ICEs in reading and seminar groups were similar ($p > .05$). In both forums, ICEs in replies tended to be higher than ICEs in postings, however difference was only significant ($p < .05$) in the seminar forums.

In contrast, ISCE and ISE indicators, in which "No-knowledge" labels are considered, were significantly higher ($p < .05$) in reading group than seminar group postings. In addition, ISCEs and ICEs index averages for the postings were significantly higher than these indexes for replies in both forums. This indicated, replies contained significantly more text labelled with "No-knowledge" tag than the postings.

The RCMs for students' contributions in reading and seminar groups were quite similar. Due to this similarity, RCM's for only reading group postings and replies are pre-

Table 4

Indexes of students' social and cognitive engagement

Discussion forum		ICE		ISCE			ISE		
		P	R	P^{**}	R		P^{**}	R	
Reading groups	n	2016	302	2215	458		2215	458	
	$M(SD)$	2.21 (0.97)	2.29 (1.14)	1.96 (1.12)	1.41 (1.39)	***	0.12 (0.3)	0.39 (0.46)	***
Seminar groups	n	567	169	660	276		660	276	
	$M(SD)$	2.14 (0.96)	2.45 (1.22) *	1.77 (1.15)	1.40 (1.47)	***	0.17 (0.36)	0.43 (0.47)	***
ANOVA$^{\alpha}$		$F(3, 354) = 3.54$, $p < .05$		$F(3, 1219) = 31.07$, $p < .001$			$F(3, 779) = 81.76$, $p < .001$		

Note. P – postings; R – replies; n – number of messages. $^{\alpha}$ Welch F ratio and Games–Howell post hoc tests: $^{*} - p < .05$; $^{**} - p < .01$; $^{***} - p < .001$. Stars (in P and R columns) indicate significant differences between means of reading and seminar groups (postings and replies, respectively). Stars in third rows, for each index, rows indicate significant differences between posting and reply means within a group. All indexes calculated for labelled students' messages only.

sented (Table 5). The RCMs showed a dominance of the "Proposing" category. The conditional co-occurrences of this category with the other four categories ranged from 0.66 to 0.84 (row 1-P). The conditional co-occurrences of "Reflecting" category in postings were second highest; ranging from 0.44 to 0.71 (row 4-R). The lowest co-occurrences of "Reflecting" were with lower cognitive level categories (i.e., "Proposing" and "No-knowledge"), while these co-occurrences gradually increased with higher cognitive level categories (i.e., "Investigating" and "Elaborating"). The "No-knowledge" category had similar conditional presence in all knowledge vectors, ranging from 0.29 to just 0.33 (row 0-N). A quarter (0.25) of all "No-knowledge" labels was used alone in postings (cell 0-N, 0-N). "Proposing" and "Reflecting" categories had high singularities as well, 0.18 and 0.11, respectively (diagonal). The collocation capacities (CC) of the categories ranged from 1.50 to 1.75, indicating that labels from these categories were, on average, collocated with labels from less than 2 other categories. In contrast, "Investigating" and

Table 5

Relative Collocation Matrixes for students' postings and replies in the reading group forums

(a) Postings

	1-P	2-I	3-E	4-R	0-N
1-P	0.18	0.82	0.84	0.76	0.66
2-I	0.26	0.03	0.33	0.28	0.20
3-E	0.36	0.44	0.03	0.42	0.29
4-R	0.55	0.63	0.71	0.11	0.44
0-N	0.32	0.31	0.33	0.29	0.25
CC	1.50	2.21	2.21	1.75	1.60

(b) Replies

	1-P	2-I	3-E	4-R	0-N
1-P	0.38***	0.23***	0.47***	0.24***	0.21***
2-I	0.17**	0.42***	0.32	0.13**	0.14*
3-E	0.18***	0.17***	0.13**	0.18***	0.09***
4-R	0.19***	0.14***	0.38***	0.44***	0.15***
0-N	0.42	0.39	0.45	0.37	0.57***
CC	0.96	0.93	1.62	0.92	0.59

Note. Coding categories: 1-P – proposing; 2-I – investigating; 3-E – elaborating; 4-R – reflecting; 0-N – no-knowledge. CC – Collocation Capacity. Significant differences (χ^2 test) between the conditional probabilities in students' postings and replies: $^{*} - p < .05$; $^{**} - p < .01$; $^{***} - p < .001$.

"Elaborating" categories had relatively small solo conditional probabilities (both equal 0.03), but high collocation capacities (both equal 2.21) indicating that labels from these categories rarely appeared alone in postings.

The RCM for replies was different. The conditional co-occurrences of all categories ranged from 0.09 to 0.47 and most values were significantly lower than for postings (Table 5). The highest co-occurrence values were for the "No-knowledge" category (row 0-N). In contrast, conditional singularities for all categories were high (diagonal). Singularity was particularly high for the "No-knowledge" category (0.57), indicating that more than half of replies containing the "No-knowledge" label did not include additional knowledge labels. The collocation capacity (CC) of the "No-knowledge" category was just 0.59, indicating that this label was often used alone in students' replies. The collocation capacities (CC) of other labels varied from 0.92 to 1.62, but were generally low, indicating that students' replies often contained one cognitively consistent idea.

4.3. *Students' Online Learning Experience*

At the end of the course, students ($n = 87$) answered multiple choice questions (5-point scale) about the following aspects of their online learning experience: (a) efficiency of interaction with peers and group work ("My interaction with peers and our group work was effective in the on-line environment"); (b) impact of the teachers' feedback on their learning ("The teachers' feedback on our on-line postings assisted my leaning"); (c) involvement in learning community ("In the on-line part of the course I felt I was part of group of people who were committed to learning"); and (d) intellectual engagement in the course ("I found the on-line component of the course intellectually stimulating"). Students' opinions regarding the course were modest (Fig. 1). On average, students agreed that schoolteachers feedback had a positive impact on their learning, $M = 3.82$,

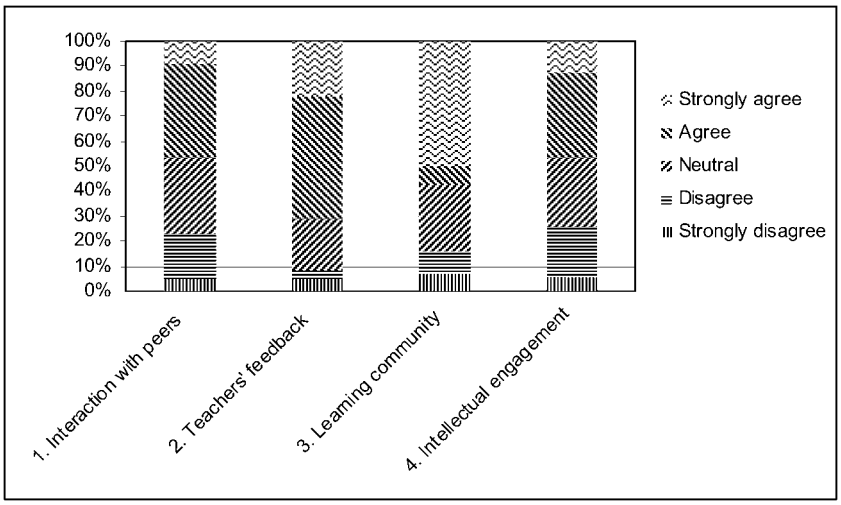

Fig. 1. Students' opinions about the online learning experience ($n = 87$).

$SD = 0.98$. Students also agreed that they felt involved in online learning community during this course, $M = 3.68$, $SD = 0.88$. However, students were quite neutral agreeing that their interaction with their peers was effective, $M = 3.28$, $SD = 1.02$; and that the course's online component was intellectually stimulating, $M = 3.28$, $SD = 1.10$. Students' responses to all four items did not correlate ($p > .05$) to ICE, ISCE and ISE.

5. Discussion and Conclusions

5.1. *Levels of Interaction in the Online Learning Community*

A large and complex online learning community, consisting of more than 200 participants with various levels of experience (i.e., students vs. expert educators) and nature of expertise (i.e., schoolteachers vs. university academics), lasting over a 12-week period, was created and analysed in this study. Such extensive studies of online learning are still rare in educational research (Zenios *et al.*, 2004).

Despite network size, levels of participation and interaction among the students were not high. The students posted just slightly more than the required course minimums and rarely responded to others. There are several explanations of this students' behaviour. First, it is possible that low students' involvement was not related to specific features of the course. Minimal levels of students' participation and interaction in online learning activities are a typical phenomenon in higher education (Fox and MacKeogh, 2003; Hew and Cheung, 2003a, 2003b; Levin *et al.*, 1990); and few research projects reported higher levels of participation (Fahy, 2001). Nevertheless, intensity and depth of interactions could be affected by online activity aims, which had strong individual learning components (i.e., reading and reflection), and limited time allocated for discussing each reading (i.e., one week). A strong impact of structural elements of online discussion protocols on students' interaction and meaningful engagement was found in various research (An and Levin, 2003; Gilbert and Dabbagh, 2005). The relationship between the time allocated for reflecting and responding and the extend and quality of discussions was observed in some studies too (Fox and MacKeogh, 2003; Ng and Murphy, 2005).

The structural-interaction parameters have shown, overall, discussions were more intensive, interactive, and deep in seminar forums, rather than reading groups. Design of the online activity may have triggered these differences in interactivity. Teachers were asked to respond to student postings in the seminar forums only, which could have automatically enhanced seminar discussions. Nevertheless, other structural-interaction parameters indicated that the students were more engaged in the seminar group discussions with schoolteachers and academics than in reading group discussions with only peers. In line with this, the survey data showed students' rating of experienced teachers' feedback and its contribution to the development of their professional knowledge was high. This was in contrast to students' lower rating of interaction efficiency with peers. These finding indicated, expert participation in online learning communities could enhance students' involvement in professional online dialogues and improve their online experiences. However, care is needed to ensure students have sufficient time to engage in on-going dialogue.

5.2. *Students' Knowledge Discourses in the Online Learning Community*

In terms of engagement with content, students wrote long and comprehensive initial postings with their individual summaries of readings in group forums. Their contributions were about 25% longer than the required 300 words, and, on average, were labelled with the labels from two different categories. While the majority of postings included some text that could be suggestive of a low cognitive engagement in the knowledge building (i.e., propositions), about half of the postings also included text that was indicative of a high level of students' cognitive engagement (i.e., reflections). The inclusion of lower cognitive level text was most likely related to the nature of the task; many students preferred to provide an individual synopsis of readings before discussing and reflecting issues more critically. These findings were inline with An's and Levin's (2003) theoretical proposition about the structure of the "reading reflection discourse" and the results of empirical studies. A number of studies have found that expository statements quite often dominated students' online discourses (Gunawardena *et al.*, 1997; Herring, 1996; Wallace, 2003).

This research has proposed and applied four advanced structural-qualitative measures in content analysis of online contributions. Two measures – the Index of Cognitive Engagement (ICE) and Index of Social Cognitive Engagement (ISCE) – were used to characterise an average level of students' cognitive engagement with the content. One additional measure – the Index of Social Engagement (ISE) – provided a numerical value for the amount of non-cognitive information in students' messages. The ISE showed, on average, students' contributions contained approximately 10% of no knowledge information. The ICE and ISCE values, however, were sufficiently high to indicate that students went beyond social interactions or simple reading summaries and were engaged with higher-level knowledge discourses. This result aligned with previous studies which have observed that initial information statements had been often followed by deeper level judgements, inferences or reflections (Fahy *et al.*, 2001; Hew and Cheung, 2003a, 2003b; Ng and Murphy, 2005).

The fourth structural-qualitative indicator – the Relative Collocation Matrix (RCM) – was developed to indicate the collocation of knowledge categories in the message and provided further insights into students' knowledge building. Analysis revealed differences between structural-content features of students' contributions in small reading and large seminar group forums were quite small, i.e., students' knowledge discourse structures were quite similar in both forums. Nevertheless, there were substantial differences between the content characteristics and discourse structures of the students' postings and replies. This suggested that the students engaged with the indivi dual and collaborative knowledge-building discourses quite differently.

Deeper analysis of the students' postings using the RCM showed, individual knowledge discourses were quite elaborated and various combinations of knowledge categories were manifested in postings. Students wrote fairly little text which was labelled with tags belonging to medium level – "Investigation" and "Elaboration" – categories. The low singularities of these categories indicated that this medium cognitive level text might have an

important mediating role in the knowledge building. The RCM showed, the conditional probabilities of knowledge labels tended to increase from the left side of the matrix to the diagonal, and then tended to decrease. This trend indicated that with the occurrence of a higher phase (i) cognitive event, the conditional probability of the co-occurrence of the next level ($i + 1$) cognitive event gradually increased. This finding suggested, students more successfully progressed from the initial propositions to the final applications and reflections if they constructed discourses gradually and wrote some intermediate cognitive level text (i.e., investigations, elaborations). As students typically find reflection difficult, this finding has important implications for online course developers. Organising learning activities enabling students to engage gradually in knowledge building by progressing from expository statements to deeper investigation should enhance their ability to engage in critical reflection.

Students' replies were significantly shorter than original posts. Deeper analysis suggested that replies probably served two different purposes: social and knowledge-building. Differently from the postings, replies were usually labelled by tags belonging to one or two categories, indicating that these often contained a single specific idea. A significant number of replies were either unlabelled or contained no knowledge text. The ICE showed that about 40% of the text in students replies were "No-knowledge" information. This indicated, students' responses tended to be more spontaneous, social and not always directed to systematic inquiry. These findings were comparable with results from other studies, which have found that postings on average were two to three times longer than replies (Nisbet, 2004), and approximately 10% – 30% of the message text was coded as different types of social or no knowledge information (Ng and Murphy, 2005). As the literature suggests (Duffy *et al.*, 1998), knowledge scaffolds are not necessary for the conversational communication. Therefore, it is likely that students quite often left the default label in their replies for the latter reason. Nevertheless, ICE for replies was even higher than for the postings. This indicated that students sometimes responded by writing succinct, but knowledge-focussed investigations, elaborations and reflections.

Taken together these results suggested that students were engaged with reflective individual and collaborative knowledge building, as identified through higher engagement levels. This result is also supported by the survey answers, which indicated that a majority of students felt part of a community committed to learning.

5.3. *Methodological Limitations and Implications*

Content analysis of students' online learning contributions provides information supporting the knowledge building process (Kanuka and Anderson, 1998) and is considered a key methodology for evaluating the educational value of online learning (Ng and Murphy, 2005). Content analysis studies typically focus on coding learning transcripts and counting coded categories (Herring, 2004). This study aimed to extend previous research methodologies and approached content analysis questions in a different way, using *a priori* defined coding scheme and students' (i.e., discourse owners) coding of their contributions (i.e., attached knowledge labels). The paper focused on analysis of coded text and

has proposed additional structural-qualitative content analysis measures for examining large volumes of online transcripts. This study demonstrated how online collected data and new content analysis measures could be applied, generating additional summative information about students' engagement in knowledge building in large online courses.

The introduced metrics are based on ordinal values assigned to levels of cognitive engagement (Table 1). As in all social research, using ordinal categorisations and mathematical operations with numerical categories, there is an inherited limitation associated with equality of intervals between successive categories, and subsequently validity and reliability of the results (Andrich, 1978). For this reason, new metrics were used and interpreted in combination with frequencies and other traditional measures of content and interaction analysis. The results, when interpreted with other traditional measures of content analysis, revealed important new aspects about students' engagement in knowledge building, and have practical implications for development of courses.

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Individualus ir grupinis žinių konstravimas virtualioje mokymosi bendruomenėje

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Straipsnyje nagrinėjamas studentų įsitraukimas į mokymosi procesą ir žinių konstravimą virtualioje mokymosi bendruomenėje. Aprašomas universiteto kursas, kuriame ugdymo procesas rėmėsi socialinėmis kultūrinėmis ir socialinėmis kognityvinėmis pedagoginėmis idėjomis: mokymasis profesinėje bendruomenėje; refleksyvusis profesinis ugdymasis; žinių konstravimas individualiai ir bendradarbiaujant. Virtuali mokymosi bendruomenė buvo sudaryta iš universiteto studentų (būsimųjų pedagogų) ir ekspertų (patyrusių bendrojo lavinimo mokyklų mokytojų ir universiteto dėstytojų). Studentai gilino savo profesines žinias skaitydami ir apibendrindami mokslinius straipsnius ir aptardami juos vienas su kitu bei ekspertais nevienalaikiame diskusijų forume. Studentų bendradarbiavimas nagrinėjamas taikant socialinių tinklų analizės metodus. Jų žinių diskursų struktūros nagrinėjamos taikant tradicinius ir naujai siūlomus turinio analizės metodus. Rezultatai atskleidė keletą svarbių tendencijų. Studentai aktyviau įsitraukė į diskusijas bendruose su ekspertais forumuose ir buvo mažiau aktyvūs tik studentų forumuose. Studentų individualūs apibendrinimai buvo nuodugnūs, išplėtoti ir glaudžiai susiję su kurso turiniu ir žiniomis. Jų atsakymai buvo trumpi, dažniausiai susiję su viena konkrečia idėja ir dažnai juose būdavo tiesiogiai su kursu ir žiniomis nesusijusio teksto. Apibendrinant straipsnyje teigiama, kad studentai virtualioje mokymosi bendruomenėje konstravo savo žinias mokydamiesi individualiai ir bendradarbiaudami. Remiantis rezultatais, straipsnyje pateikiamos praktinės rekomendacijos, kaip geriau organizuoti mokymąsi tokiose bendruomenėse.