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Students' Level of Knowledge Construction and Pattern of Social Interaction in an Online Forum

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***Abstract*—**The asynchronous discussion forum is one of the most widely used activities in learning management system environment. Online forum allows participants to interact, construct knowledge, and can be used to complement face to face sessions in blended learning courses. However, to what extent do the students perceive the benefits or advantages of forum remain to be seen. Through content and social network analyses, instructors will be able to gauge the students' engagement and knowledge construction level. Thus, this study aims to analyze the students' level of knowledge construction and their participation level that occur through online discussion. It also attempts to investigate the relationship between the level of knowledge construction and their social interaction patterns. The sample involves 23 students undertaking a master course in one public university in Malaysia. The asynchronous discussion forum was conducted for three weeks as part of the course requirement. The finding indicates that the level of knowledge construction is quite low. Also, the density value of 0.11 indicating the overall communication among the participants in the forum is low. This study reveals that strong and significant correlations between SNA measures (*in-degree centrality*, *out-degree centrality)* and level of knowledge construction. Thus, allocating these active students in different group aids the interactive discussion takes place. Finally, based upon the findings, some recommendations to increase students' level of knowledge construction and also for further research are proposed.

***Keywords*—**Asynchronous Discussion Forums, Content Analysis, Knowledge Construction, Social Network Analysis.

I. Introduction

LEARNING Management System (LMS) or Content Management System (CMS) is considered highly relevant and applicable in the field of education. It is a platform used to deliver online learning materials. LMS is a software application which enables educators to manage and implement online instruction. Several common LMSs include Moodle, Blackboard, and WebCT. Essentially, the forum has become one of the most widely used activities for teaching and learning in LMS environment.

It provides space for students to make careful preparations as providing contributions or ideas with reference either before giving feedback, critique and comment on the posts in the discussion sessions. Asynchronous discussion can improve students' understanding [2] and achievement [3].

However, some of the findings on the use of asynchronous discussion forums are of concern to educators. For instance students' involvement in an online discussion forum is still at a low level [4]. Also, students are more likely to focus only on selected forums [5]. On the other hand, other researchers [6] found that students are more eager to answer their peers' questions. They are also often scared and afraid to question the idea of their friends [7]. Besides that, the presence of instructors in discussion forums makes students feel less confident to express their ideas [8]. These are some of the barriers in achieving a higher level of knowledge construction. Meanwhile, [1] also found that higher knowledge construction rarely applicable among the learners. Thus, there is the necessity to look at the students' level of knowledge construction to extend further evidence in online discussion.

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II. Content Analysis

Content analysis is an effective technique for researchers to get a better understanding of the cognitive processes and the quality of online learning [1]. In this study, researchers have chosen to use the model of [1] known as the Interaction Analysis Model (IAM). Thus, in this study content analysis was carried out to obtain a deeper understanding on the quality of social interaction of each student that involved in the process of learning and knowledge co-construction in online discussion forums. According to [1], the knowledge construction process involves five phases, namely (i) Sharing/comparing information (Phase I), (ii) Discovery of dissonance (Phase II), (iii) Negotiation of meaning (Phase III), (iv) Testing and modification (Phase IV) and (v) Application of newly constructed knowledge (Phase V).

III. Social Network Analysis

Another supporting or an alternative tool that has been used to analyze students' engagement in online forums is Social Network Analysis (SNA). Social network analysis has proven to be a resource to assess the overall pattern of social interaction and exchange of information that occurs in the discussion forum as a whole [9]. In addition, SNA can also reveal the patterns of communication and interaction structures [9]. The variables that can be used to analyze individual behaviors in SNA are the *centrality* (*degree*, *closeness*, *betweenness*) and *density* [9].

According to [10], network participants can show the importance or become prominent because (a) they have more direct contact with other participants (*degree centrality*), (b) they have closer position with other individual participants (*closeness centrality*), or (c) is in the advantageous position of the other participants (*betweenness centrality*). *Centrality*

measures who are central (powerful) or isolated in networks. *In-degree centrality* indicates the number of the messages received from others; meanwhile *out-degree centrality* indicates the messages that sent to others. *Closeness centrality* is the average degree to which an individual is close to other participants within the network [11]. The smaller the *closeness* value, the closer the participant to others and indicates that the information can be easily transferred directly to that participant in the network/ forum. Meanwhile a higher *closeness* value indicates that the information needs to travel through other participants in order to reach a particular participant.

Betweenness centrality refers to the extent a node lies between other nodes in a network [11]. This participant can control the flow of information between students. Node with high *betweenness centrality* has great influence on the flow of information within the network. *Eigenvector centrality* is a measure of a participant's interaction with the other highly interactive participant or the tendency of interacting with the less active participants in the group. *Eigenvector* value provides an overview on how group members interact and how they have developed strong relationships with influential members or other active members within the group. Another variable that can indicate students' involvement in the network as a whole is *density*. *Density* is a proportion that indicates the number of actual ties present in the group relative to the number of possible ties in the group [12]. If the *density* is 0, it indicates that the network does not have any communication or contact between its participants and conversely, if *the density value* of a network is 100%, this shows all students communicate to one another.

Thus, through social network analysis, students' participation and the structure of their interactions can be examined. In addition, the investigation on the relationship between content analysis and social network analysis can provide useful information involving both cognitive processes and complex social interactions that occur through online discussion.

IV. Objectives

The objectives of this study are;

1) To evaluate the level of knowledge construction in asynchronous discussion forum.
2) To examine the students' participation and their structure of their interactions in asynchronous discussion forum.
3) To investigate the relationship between the level of knowledge construction and the social networking.

V. Methodology

A. Participants and Learning Task

The samples involve 23 postgraduate students undergoing a master program in a public university in Malaysia. A course was chosen in this study, which is taught in a blended format. The students had to attend classroom meetings (once in a week for a two hour lecture) as well as online learning sessions (participation in the forums is required on a weekly basis before attending the classroom session).

B. Data Extraction and Processing (Quantitative Content Analysis is used IAM- Code System)

Content analysis was carried out on the messages posted by the participants in the forum, in which those messages are in the form of input or questions. Table I details the coding system of each phase using the Interaction Analysis Model or IAM rubric [1] which consists of five phases of knowledge construction. In this quantitative content analysis, the coding was done by two independent coders, where initially both coders discussed and described each stage, using the examples of each stage in the IAM. Then the coders evaluated the posts separately. There were a total of 182 posts and course coordinator's data were excluded from this analysis. Cohen's Kappa values for the inter-rater reliability were 0.89 for this study.

TABLE I
Interaction Analysis Model (IAM) [1]

Phase	Description
Phase I	Sharing and comparing information
Phase II	Discovery and exploration of dissonance or inconsistency among participants
Phase III	Negotiation of meanings or knowledge co-construction
Phase IV	Testing the proposed new knowledge and modification meanings against existing experiences
Phase V	Phrasing of agreement and applications of newly constructed meaning

C. Analysis

The students' participation in the online forum was analyzed based on the frequency of discussions or tasks carried out and recorded in the LMS. For this purpose, Social Networks Adapting Pedagogical Practice (SNAPP) - a social network analysis tool - was used to process the *degree* (*in-degree*, *out-degree*), *betweenness centrality and eigenvector centrality* data. In addition, the network *density* and *closeness* data were obtained from Netdraw.

The values for *degree centrality*, *closeness centrality*, *betweenness centrality*, *eigenvector centrality* and *density* are split into higher quartile and lower quartile. Students' engagement is considered high if the posts / responses in the forum identified on the third quartile; the engagement is considered low if they are found in the first quartile [13].

D. Data Correlation between Level of Knowledge Construction and Social Network Analysis

The Pearson correlation coefficient was used to investigate the correlation between the mean level of knowledge construction (IAM) for each student with the *degree*, *closeness centrality*, *betweenness centrality* and *eigenvector centrality*.

VI. Findings

A. Content Analysis (Knowledge Construction Levels)

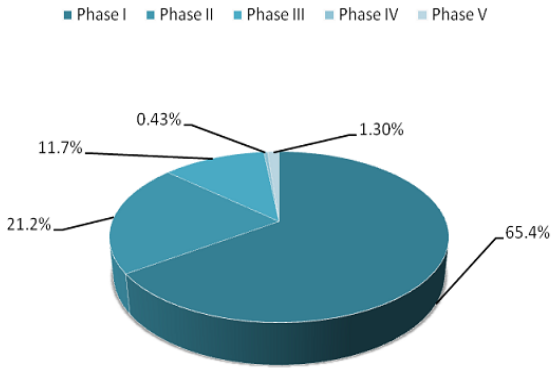

Fig. 1 Distribution for each phase of the knowledge construction

Although the samples in this study involved 23 students, only 21 participate in the forums. There are altogether 182 posts/ messages (Fig. 1) and the majority of the posts are in Phase I, followed by Phase II. Phase 1 consists of 117 messages (64.3%) and Phase II involves 49 messages (27.0%). Only 8.7% of the posts involve the combination of phase III, IV and V. Phase III consists of 11 messages (6%), Phase IV consists of three messages (1.6%) meanwhile Phase IV consists of two messages (1.1%). According to [1], Phase 1 and Phase 2 are indicating the lower levels of knowledge construction, meanwhile Phase III, IV and V which are associated with higher levels of knowledge construction. Overall, the finding indicates that the levels of knowledge construction among the forum participants are quite low.

TABLE II
Classification of Students' Message's Contents

Phase	Description	Results
Phase I	Sharing and comparing information	117 messages (64.3%)
Phase II	Discovery and exploration of dissonance or inconsistency among participants	49 messages (27.0%)
Phase III	Negotiation of meanings or knowledge co-construction	11 messages (6.0%)
Phase IV	Testing the proposed new knowledge and modification meanings against existing experiences	3 messages (1.6%)
Phase V	Phrasing of agreement and applications of newly constructed meaning	2 messages (1.1%)

The outcomes (Table II) indicated that there are not much influence on higher level of knowledge construction on the sharing of information. This means students tend just to share their thoughts, ideas, resources, experience or agree with their peers' opinions. In other words, there is little disagreement among the participants of the forum, resulting in the interaction of the students remain in phase I. Further, only 6% of these messages indicate the negotiation of meaning where participants negotiate meaning or build knowledge together to propose solutions to the problems faced. This suggests that online learning should provide opportunities for students to collaborate and lead to the construction of new ideas has not been achieved as a whole. Due to the lack of discovery and exploration of dissonance (Phase II) and negotiation of meaning (Phase III), there is not much testing or modifications to the proposed new knowledge (Phase IV), which is only 1.6%. This resulted in only 1.1% of messages related to the construction of new knowledge (Phase V).

B. Social Network Analysis (SNA)

1. Degree Centrality

Table III shows the range of *out-degree* and *in-degree* value is between zero to six (except for the course coordinator). The participants who gained high *out-degree* values in the forums are HIL (6), SIT (4), KAR (4) and FAI (4). KOM and SOR have zero *degree* of interaction (indicating that no interaction exists between them and the other participants in the network). RAJ is reported to have the highest *in-degree* value (six) while FAI and ATI have five and four respectively. This is followed by HIL, LIM and SUK who scored an *in-degree* value of three. It was found that 13 out of 23 participants are with zero *in-degree* (no one responded to their posts).

2. Closeness Centrality

Referring to Table III, the *closeness* value is between 36 and 59. RAJ has the lowest *closeness* value of 36 followed by ATI (37), indicating that they are the closest participants to the others in the discussion. NIZ and NAZ indicated the highest *closeness* value of 59 which means they are the farthest in terms of engagement from their peers.

TABLE III
Value of Degrees (In-Degree, Out-Degree), Closeness Centrality, Betweenness Centrality, Eigenvector Centrality and Density

Num	Students' name	*Degree (s)*	*In-degree (s)*	*Out-degree (s)*	*Closeness centrality*	*Betweenness Centrality*	*Eigenvector centrality*
*	INU	20	20	0	27	128	0.524
1	HIL	9	3	6	39	24	0.289
2	FAI	9	5	4	41	5	0.261
3	KAR	6	2	4	40	10	0.269
4	SIT	4	0	4	43	1	0.253
5	RAJ	9	6	3	36	11	0.371
6	MAR	4	1	3	40	18	0.217
7	LIM	6	3	3	40	19	0.263
8	ERF	2	0	2	46	0	0.139
9	ATI	6	4	2	37	32	0.276
10	KHA	2	0	2	45	0	0.144
11	LEE	2	0	2	57	2	0.055
12	SUK	5	3	2	49	8	0.103
13	NIZ	2	0	2	59	1	0.036
14	AZA	3	1	2	44	12	0.100
15	HAF	2	0	2	47	0	0.093
16	NAZ	1	0	1	59	0	0.051
17	MAH	1	0	1	57	0	0.049
18	VAS	1	0	1	47	0	0.093
19	RAD	1	0	1	47	0	0.093
20	GEE	2	1	1	57	2	0.048
21	PUR	1	0	1	47	0	0.093
22	SOR	0	0	0	0	0	0
23	KOM	0	0	0	0	0	0

*Course Coordinator

3. Betweenness Centrality

Based on Table III, the participants who gained high *betweenness* values in the forums are ATI (32), HIL (24), LIM (19), MAR (18) and AZA (12).

4. Eigenvector Centrality

The eigenvector centrality of the forum participants are 0.036 and 0.371. NIZ has the tendency to interact with inactive members as he/she obtained the lowest eigenvector centrality value which is 0.036. Conversely, RAJ had the highest value which is 0.371 indicating his/her tendency to interact with the active members. The majority of the participant's eigenvector centrality (12 participants) is in the range 0-0100.

5. Density

The overall communication among the participants in the forum is low as the network *density* value is 0.11.

C. Correlation between Level of Knowledge Construction and Social Network Analysis

Pearson's correlation coefficient (*r*) (Table IV) was utilized to examine the relationships between the level of knowledge construction and SNA variables such as in-*degree centrality*, *out-degree centrality*, *closeness centrality*, *betweenness centrality* and *eigenvector centrality*. Significant and strong correlations were observed between (i) *in-degree centrality* and level of knowledge construction (r = 0.806), (ii) *out-degree centrality* and level of knowledge construction (r = 0.718) and (iii) *eigenvector centrality* and level of knowledge construction (r = 0.706). Meanwhile the analyses indicate significant and moderate correlation (r = 0.425) between the *betweenness degree* and level of knowledge construction. On the other hand, examination of the *closeness centrality* between the level of knowledge construction revealed very weak, but insignificant correlation (r = 0.245).

TABLE IV
PEARSON'S CORRELATIONS COEFICSCIENT BETWEEN IAM AND DEGREE (IN-DEGREE AND OUT-DEGREE), CLOSENESS CENTRALITY, BETWEENNESS CENTRALITY AND EIGENVECTOR CENTRALITY (N=23)

Variables	Mean	Std	Phase
In-degree centrality	1.26	1.839	.806**
Out-degree centrality	2.13	1.423	.718**
Closeness centrality	42.47	15.13	.245
Betweenness centrality	6.30	9.132	.425*
Eigenvector centrality	.14	.107	.706**
Phase	1.26	.810	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

VII. DISCUSSION

A. Content Analysis (Knowledge Construction Levels)

The findings of this study showed that the highest percentage of interactions occur in Phase I, which is consistent with studies by [1], and [14]. In the study by [1], it showed the following findings; Phase 1 (93%), Phase II (2.4%), Phase III (1.9%), Phase IV (1%) and Phase V (1.9%). According to them, students constructed knowledge by moving from lower to higher mental functions, which means they usually start by sharing and comparing information before reaching higher levels such as negotiating, testing, and applying ideas collaboratively. According to [7], one of the major limiting factors in achieving higher knowledge construction is because students are often scared and afraid to question the idea of their peers. Similarly, studies by [6] found that students were more interested in responding to peers' questions only without further elaboration given, resulting low level knowledge construction. In order to create a quality and interactive discussion, students should read the existing messages in the forum before posting their messages [15]. Also, students need to understand by involving and expressing different points of view or criticizing others will not disrupt harmonious relationships among themselves. Thus, instructors need to encourage the students to develop positive attitudes toward engaging themselves in the discussion in order to create new knowledge and achieve higher thinking level.

B. Social Network Analysis

There are a few students who had a minimal degree of interaction in the discussion forum. Those students are KHA, PUR, GEE, KOM, and SOR. They have the risk of becoming low performing students in the class as highly engaged students in the discussion have the potential to achieve higher overall final grades [16]. Moreover, the analysis has identified 11 students (KHA, NIZ, LEE, ERF, HAF, NAZ, MAH, PUR, SIT, VAS and RAD) who posted their messages in the forum but did not receive any feedback from others. According to [13], when the post sent uninspiring others, this will cause others not to reply. These 11 students were also reported to have a low-level of interaction in the overall online forum session. As such, according to [17], low interaction students are usually associated with lower grades [17]. Also, students with lower grades mostly are not fluent writers and readers as they may face difficulty in expressing themselves through the text and this is supported by previous studies [13].

The findings are similar to previous studies by [18] which concluded that participants tend not to form strong connections among peers in an instructor driven forum. Conversely, they are highly connected to the course instructor. Based on this analysis, five participants, namely ATI (32), HIL (24), LIM (19), MAR (18), AZA (12) and also INU (128, course coordinator) who obtained the highest *betweenness centrality* values. The difference of range in *betweenness centrality* values between students and course coordinator indicates that the participants tend to communicate to the coordinator more than to their peers. This finding is also consistent with previous studies where instructor involvement demonstrates responsiveness to students, but this may influence on students' response to peers [18].

C. Relationship between Level of Knowledge Construction and Social Network Analysis

This study reveals that strong and significant correlations between SNA measures (*in-degree centrality*, *out-degree centrality*, and *eigenvector centrality)* and level of knowledge construction. A moderate and significant correlation was

observed between *betwenness centrality* and levels of knowledge construction. Also, there is no correlation between *closeness centrality* and level of knowledge construction. However, this finding contradicts that of [19] who found that no significant correlation between the level of knowledge construction with *in-degree*, *out-degree* and *betweenness centrality*. There are no other studies being done on the correlations between the level of knowledge construction and SNA measures.

There is a correlation between *in-degree centrality* and level of knowledge construction as the participants with a higher level of knowledge construction usually receive more messages, replies, and feedback. Other participants tend to communicate more to this group of participants as they have more knowledge or information. The same notion goes to the participants with higher *out-degree centrality* value who has more knowledge or information. This indicates a correlation between level of knowledge construction and *out-degree centrality*. Those participants tend to be involved more in the discussions and gave more input to others. In addition the relationship between level of knowledge construction and *eigenvector centrality* values confirmed that the participants with a higher level of knowledge construction tend to communicate with active participants. Furthermore, the weak correlation between a higher level of knowledge construction and *betweenness centrality* values shows that participants with a higher level of knowledge construction not necessarily control the flow of information among the participants. Thus, although there is a correlation between these variables, this influence is weaker on one another. On the other hand, there is no correlation between level of knowledge construction and *closeness centrality* values – indicating that the participants with higher knowledge construction levels not necessarily communicate with certain groups of students. Therefore, they are closely connected to all other participants in the network.

VIII. Implication of Findings

Limited interactivity levels indicate that participants did not really focus their attention on their peer's idea. Besides that, according to [15], in order to produce a two-way communication and quality discussion, the participants need to read existing posts before sending own post. Implementing much smaller collaboration in which each group member is given a certain responsibility in discussing the given topic can resolve low interaction level. This collaborative learning approach can assist students to develop a more meaningful knowledge compared to an individual learning [20]. In addition, an alternative way to simplify the process of discussion by electing student moderators each week to be responsible facilitating the discussion [21]. Other researchers [22] found that peer mentoring can promote active learning and meaningful as they rely on each other in a discussion. Essentially, the presence of the instructor is required at the beginning of the learning process to correct the misunderstanding, and instructors can maintain their presence to a minimum to encourage the discussion process [23].

Meanwhile, [14] suggested that individuals should send a post as the basis for a discussion of certain on-line before it reaches the generation of knowledge at a high level. Besides, according to [1], individual construct knowledge by interacting with others means that more interactions would lead to higher levels of knowledge construction. In addition, the assignment must also be matched with existing knowledge and skills of the students because if the task is too complex discussion then the level of knowledge construction will be lower [14]. Also, the success of the discussions is depending on the topic of discussion or question which is more specific than the broad and more open questions [24]. Thus, instructors should provide adequate and full instructions in order to encourage the students to complete the discussions in advanced [14].

Social Analysis Network allows instructors to identify students' patterns and levels of social interaction in online discussion forums. This information may assist instructors to identify the tendency of low achieving students. Additionally, in this study, SNA has shown that correlations exist between the SNA variables (*in-degree centrality, out-degree centrality, eigenvector,* and *betweenness degree)* and level of knowledge construction. These findings suggest that students with the highest *degree centrality* should be grouped in different discussion groups for interactive discussion take place. Besides, participants with higher *betweeness centrality* values also contribute as they control the flow of information between students. Allocating these students in different groups aids the interactive discussion takes place. Hence, the researchers found that using the content analysis method can facilitate the instructors to measure the students' level of knowledge construction from time to time. In addition, using content analysis and social network analysis could complement each other as these analyses can provide information inclusive of both cognitive processes and social interactions.

IX. Contribution to Knowledge

This study has made some contributions to the knowledge about online discussion forums.

1) This study combines two analyses (content analysis and social network analysis) to investigate the relationship between the level of knowledge construction and the social networking. Previous researchers usually examine only on the aspects of social network analysis and/or content analysis in their studies without looking at the correlations.
2) Next, a combination of content analysis and social network analysis gives comprehensive information on students' engagement and knowledge construction. This suggestion will contribute to the online discussion literature.

X. Recommendations for Future Studies

1) A study using a collaborative learning approach is proposed with combination of content analysis and social network analysis to be implemented to evaluate the

collaborative approach.

2) Study of cluster analysis to classify the behavior of participants in an online forum is proposed. The combination of using different methods of analysis such as content analysis, social network analysis and cluster analysis could provide different information on the subjects. Each analysis has its own limitations which can be compensated for by using an alternative method to collect comprehensive findings.

XI. Conclusion

The effectiveness of asynchronous discussion forums to facilitate teaching and learning depends on the process undertaken, for example, students' role, the extent of academic discussions carried out, the quality of students' interaction and participation. Without the involvement of students as a whole, the benefits of forum in assisting their learning will not be achieved.

References

[1] C. Gunawardena, C. Lowe and T. Anderson, 'Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing', *Journal of educational computing research*, vol. 17, no. 4, pp. 397--431, 1997.

[2] M. Balaji and D. Chakrabarti, 'Student interactions in online discussion forum: Empirical research from 'media richness theory' perspective', *Journal of Interactive Online Learning*, vol. 9, no. 1, pp. 1--22, 2010.

[3] C. Cheng, D. Par\'e, L. Collimore and S. Joordens, 'Assessing the effectiveness of a voluntary online discussion forum on improving students' course performance', *Computers \& Education*, vol. 56, no. 1, pp. 253--261, 2011.

[4] P. krish, 'Participation in Online Forums: Some Insight of Malaysian Distance', 2010.

[5] V. Peters and J. Hewitt, 'An investigation of student practices in asynchronous computer conferencing courses', *Computers \& Education*, vol. 54, no. 4, pp. 951--961, 2010.

[6] W. S. Cheung and K.F Hew, 'Examining students' creative and critical thinking and student to student interactions in an asynchronous online discussion environment: A singapore case study', *Asia-Pacific Cybereducation Journal*, vol *2*, no.2, 2006.

[7] X. Liu, B. Doore and L. Li, 'Scaffolding knowledge co-construction in web-based discussions through message labeling', vol. 2008, no. 1, pp. 3041--3046, 2008.

[8] H. An, S. Shin and K. Lim, 'The effects of different instructor facilitation approaches on students' interactions during asynchronous online discussions', *Computers \& Education*, vol. 53, no. 3, pp. 749--760, 2009.

[9] P. Vercellone-Smith, K. Jablokow and C. Friedel, 'Characterizing communication networks in a web-based classroom: Cognitive styles and linguistic behavior of self-organizing groups in online discussions', *Computers \& Education*, vol. 59, no. 2, pp. 222--235, 2012.

[10] R. Hanneman, 'Introduction to social network methods', *Department of Sociology, University of California, Riverside* 2001.

[11] L. Freeman, 'Centrality in social networks conceptual clarification', Social networks, vol. 1, no. 3, pp. 215--239, 1979.

[12] R. S. Burt, 'Applied network analysis: A methodological introduction', pp. 176-194. Sage, Beverly. Hills, CA, 1983.

[13] L. Lipponen, M. Rahikainen, J. Lallimo and K. Hakkarainen, 'Analyzing patterns of participation and discourse in elementary students' online science discussion', pp. 421--428, 2001.

[14] T. Schellens and M. Valcke, 'Collaborative learning in asynchronous discussion groups: What about the impact on cognitive processing?', *Computers in Human behavior*, vol. 21, no. 6, pp. 957--975, 2005.

[15] A. Wise, J. Speer, F. Marbouti and Y. Hsiao, 'Broadening the notion of participation in online discussions: Examining patterns in learners' online listening behaviors', *Instructional Science*, vol. 41, no. 2, pp. 323--343, 2013.

[16] L. Macfadyen and S. Dawson, 'Mining LMS data to develop an "early warning system" for educators: A proof of concept', *Computers \& Education*, vol. 54, no. 2, pp. 588--599, 2010.

[17] J. Davies and M. Graff, 'Performance in e-learning: online participation and student grades',*British Journal of Educational Technology*, vol. 36, no. 4, pp. 657--663, 2005.

[18] P. Doran, C. Doran and A. Mazur, 'Social network analysis as a method for analyzing interaction in collaborative online learning environments', *Journal of Systemics, Cybernetics and Informatics*, vol. 9, no. 7, pp. 10--16, 2011.

[19] B. Vasa, 'An assessment of knowlede construction in an online discussion forum: The relationship between content analyis and social network analysis', 2010.

[20] D. Jonassen, 'Computers As Mind Tools For Schools'. Merril, Columbus: OH, 1996.

[21] A. Rovai, 'Facilitating online discussions effectively', *The Internet and Higher Education*, vol. 10, no. 1, pp. 77--88, 2007.

[22] T. Anderson and L. Rourke, 'Using Peer Teams to Lead Online Discussions', *Journal of Interactive Media in Education*, 2002.

[23] R. Kay, 'Using asynchronous online discussion to learn introductory programming: An exploratory analysis', *Canadian Journal of Learning and Technology/La revue canadienne de l'apprentissage et de la technologie*, vol. 32, no. 1, 2006.

[24] Y. Fung, 'Collaborative online learning: Interaction patterns and limiting factors', Open Learning: The Journal of Open, Distance and e-Learning, vol. 19, no. 2, pp. 135--149, 2004.