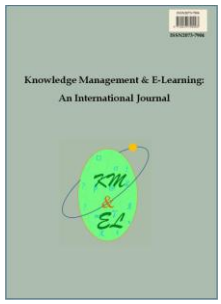
Knowledge Management & E-Learning, Vol.5, No.3. Sep 2013

Knowledge Management & E-Learning



ISSN 2073-7904

Gender differences in collaborative learning over online social networks: Epistemological beliefs and behaviors

Rosanna Y.-Y. Chan
Jie Huang
The Chinese University of Hong Kong, Hong Kong
Diane Hui
Lingnan University, Hong Kong
Silu Li
Peng Yu
The Chinese University of Hong Kong, Hong Kong

Recommended citation:
Chan, R. Y.-Y., Huang, J., Hui, D., Li, S., & Yu, P. (2013). Gender differences in collaborative learning over online social networks: Epistemological beliefs and behaviors. *Knowledge Management & E-Learning, 5*(3), 234–250.

Knowledge Management & E-Learning, 5(3), 234–250

Gender differences in collaborative learning over online social networks: Epistemological beliefs and behaviors

Rosanna Y.-Y. Chan*

Department of Information Engineering
The Chinese University of Hong Kong, Hong Kong
E-mail: yychan@ie.cuhk.edu.hk

Jie Huang

Department of Information Engineering
The Chinese University of Hong Kong, Hong Kong
E-mail: hj012@ie.cuhk.edu.hk

Diane Hui

Department of English
Lingnan University, Hong Kong
E-mail: dianehui@ln.edu.hk

Silu Li

Department of Information Engineering
The Chinese University of Hong Kong, Hong Kong
E-mail: lsl012@ie.cuhk.edu.hk

Peng Yu

Department of Information Engineering
The Chinese University of Hong Kong, Hong Kong
E-mail: yp012@ie.cuhk.edu.hk

*Corresponding author

Abstract: Online social networks are popular venues for computer-supported collaborative work and computer-supported collaborative learning. Professionals within the same discipline, such as software developers, often interact over various social network sites for knowledge updates and collective understandings. The current study aims at gathering empirical evidences concerning gender differences in online social network beliefs and behaviors. A total of 53 engineering postgraduate students were engaged in a blogging community for collaborative learning. Participants' beliefs about collaboration and nature of knowledge and knowing (i.e. epistemological beliefs) are investigated. More specifically, social network analysis metrics including in-degree, out-degree, closeness centrality, and betweenness centrality are obtained from an 8-interval longitudinal SNA. Methodologically speaking, the current work puts forward mixed methods of longitudinal SNA and quantitative

beliefs survey to explore online social network participants' beliefs and behaviors. The study's findings demonstrate significant gender differences in collaborative learning through online social networks, including (1) female engineering postgraduate students engage significantly more actively in online communications, (2) male engineering postgraduate students are more likely to be the potential controllers of information flows, and (3) gender differences exist in belief gains related to social aspects, but not individual's epistemic aspects. Overall, participants in both genders demonstrated enhanced beliefs in collaboration as well as the nature of knowledge and knowing.

Keywords: Gender differences; Collaborative learning; Epistemology, Online social networks (OSNs); Engineering education

Biographical notes: Rosanna Yuen-Yan Chan is currently an Adjunct Assistant Professor in the Department of Information Engineering, the Chinese University of Hong Kong, and was Postdoctoral Fellow in Learning Sciences in the Faculty of Education, the University of Hong Kong. Chan has a multidisciplinary background in engineering, education, and learning sciences. Her research interests include engineering education and engineering epistemologies. She received her Ph.D. degree in Information Engineering and M.Ed. degree in Educational Psychology from the Chinese University of Hong Kong. Chan has founded the Hong Kong Chapter of the IEEE Education Society, and is appointed the NAE CASEE Faculty Fellow in 2007 for her research works in engineering education.

Jie Huang, Silu Li, and Peng Yu obtained their M.Sc. degrees in Information Engineering from the Department of Information Engineering, the Chinese University of Hong Kong. They conducted research related to online social networks (OSNs) during their postgraduate studies under the supervision of Dr. Rosanna Yuen-Yan Chan.

Diane Hui is currently an Assistant Professor in the Department of English, Lingnan University and a Spencer scholar (USA). She is an experienced language and educational researcher, teaching practitioner, and language examiner. She has conducted educational research in multidisciplinary settings, spanning three cultures and three continents. Diane's research interests include sociocultural and cognitive engagement of learning within communities of practice in both formal and informal settings, discourses, popular culture and mediated-learning enhanced by technology, critical and media/new literacies through Web 2.0, learning sciences, innovation and pedagogy, and assessment for learning.

1. Introduction

Online social networks (OSNs) have changed the way in which knowledge is constructed and shared. *Facebook*, *Twitter*, and *blogs* are examples of popular online venues for knowledge exchange and social interaction. These platforms provide affordances for collective knowledge through collaboration across temporal and spatial boundaries. Wikipedia is one of the most prominent examples. There are also different kinds of online communities which aim at dynamic knowledge exchange and sharing, such as the blogging communities of academic researchers and the question-and-answer type of forums, e.g., *Yahoo! Answers* and *Quora.com.* It is salient that social network sites (SNSs) are now serving a variety of purposes in knowledge management and e-learning.

Research investigating gender differences in technology usage is noted in the literature. For example, Wang and Chen (2012) investigated the effects of gender consciousness on learning in educational games. Until recent decades, science and engineering have always been recognized as a male dominant arena, where women scientists and engineers are minorities in the fields (Sørensen, 1992). Early Web services were less "user-friendly" and required much server-side knowledge which made online publishing limited to a few users with professional knowledge in computer and network technologies. A few early studies reported that women were disadvantaged in computer supported environments (Griffiths, 1985; Spender, 1995) which led to the proposal of "women friendly cyber-environments" (Blum, 1999). Nevertheless, situation changes nowadays. In Web 2.0, the World Wide Web has become much more pervasive and accessible. Users can now produce multimedia contents and publish their works online with simple clicks. According to the International Telecommunication Union (ITU) statistics in 2010, female users made up of 47.28% of the world's Internet population (ITU, 2012). However, research concerned with females' beliefs and behaviors in online social environments is scant in the extant literature.

The current work aims at collecting empirical evidences about gender differences in OSNs as a collaborative learning environment. A total of 53 engineering postgraduate students (N = 53) were engaged in a blogging community for sharing ideas and knowledge exchange in engineering subject knowledge. The participants' OSN behavior was examined through a longitudinal social network analysis (SNA). Pretest and posttest quantitative surveys were also conducted to provide additional evidences concerning beliefs change related to collaborative learning upon OSN participation.

2. Background

2.1. Gender differences in offline and online social networks

Among the different aspects of social factors, patterns of gender differences in social network are known to be more consistent than other areas. Considerable evidence indicates that women's interaction on social networks fulfills feminine social role prescriptions for expressive, affinitive and supportive behaviors, while men's roles and interaction conform to the masculine norms of independence and instrumentality. According to early sociology research (e.g., Antonucci & Akiyama, 1987), women reported that they have larger offline social networks than men, more real-world friends, and engaged more in bidirectional interaction with other network members.

Similar patterns were also found in studies about gender differences in OSNs. For example, Joinson (2008) identified from *Facebook* users that females visited the SNSs significantly more frequently than their male counterparts did; they also scored significantly higher in gratification measurements, such as using more expressions related to social connections and the sharing of more photographs. In recent studies, Kimbrough, Guadagno, Muscanell, and Dill (2013) found that women are generally more frequent computer-mediated-communication users than men. Women also prefer, and in fact use technologies more frequently than men for social interaction and communication such as text messaging, social media, and online video calls. Fu, Yang, and Huang (2012) also found that female bloggers produced significantly more posts than males did, and they regarded gender difference as a significant factor affecting knowledge sharing.

2.2. Collaborative learning and knowledge building

Computer-supported collaborative learning (CSCL) is a major research field in Education and Computer Science (Stahl, Koschmann, & Suthers, 2006). CSCL distinguishes itself from the general e-learning practices based on the notion of "collaboration". In CSCL, participants interact socially to co-construct knowledge within a computer supported environment. CSCL is also theoretically related to knowledge building (Scardamalia & Bereiter, 1994; Scardamalia & Bereiter, 2006). As reviewed by Chan and Chan (2011), knowledge building "*emphasizes collective cognitive responsibility and engagement of students in a community to create new knowledge guided by online discourses mediated by the computer forum*" (p. 1446).

A set of 12 principles has been elaborated by Scardamalia (2002) to characterize the socio-technological and socio-cognitive dynamics involved in knowledge building, *namely improvable ideas; community knowledge; rise above; diversity of ideas; democratizing knowledge; epistemic agency; knowledge-building discourse; concurrent assessment; symmetrical advances; constructive uses of information; authentic problem; and pervasive knowledge building.* According to Scardamalia, the 12 principles intertwine and constitute into a "*complex interactive system of forces that drive the process*" (Zhang, Scardamalia, Reeve, & Messina, 2007, p. 119), and "*the inter-connectedness of these ideas mean that implementing one tends to unlock the others*" (Scardamalia, 2002, p. 77). The theoretical framework of knowledge building hence portrays collaboration as "*a notion that goes beyond the division of labor and that involves students focusing on idea improvement and collective cognitive responsibility*" (Chan & Chan, 2011, p.1446). Chan and Chan (2011) developed the Collaborative Knowledge Building (CKB) scale which consists of 12 items to measure students' beliefs related to their participation in the Knowledge Forum (Scardamalia & Bereiter, 2006), a web-based asynchronous discourse co-construction medium with two-dimensional graphical-based interface.

According to existing literature, high scores in the CKB scale are significantly correlated to deep learning (Chan & Chan, 2011), which is critical for learning in the 21st century. Students' positive change of views in collaboration also aligns with idea improvement and collective growth (Chan, Law, & van Aalst, 2008). However, these studies were conducted with secondary school students and did not have a gender focus. As the US National Academies including the National Academy of Engineering (NAE) advocate the importance of deeper learning and 21st-century competencies (National Academies, 2012) at school as well as at work and, it is important to investigate how university students' beliefs in collaboration and knowledge building may be related to (and potentially be fostered by) their OSNs participation.

2.3. Epistemological beliefs

Epistemology is a major area in philosophy that studies knowing and other desirable ways of believing and attempting to find the truth (Zagzebski, 2009). Epistemological beliefs (EB) and epistemic cognition (EC) are emerging areas in psychology and educational research. Most existing works focus on learners' EB and involved two key aspects: *the nature of knowledge* and *the nature of knowing* (Hofer & Pintrich, 2002). Students' EB have been found to be related to the key components of learning processes such as comprehension (Schommer, 1990), strategic processing, and evaluation of arguments (see a review provided by Li, Chan, Jong, Huang, and Yu (2013)). Chinn, Buckland, and Samarapungavan (2011) recently re-examined EC in accordance with

contemporary philosophical works. They suggested that epistemologists do not focus only on knowledge, but rather aim to explicate a large network of epistemic phenomena and their interrelationships (p.39).

An 18-item questionnaire has been developed by Hofer (2000) to measure individual's epistemological beliefs. The questionnaire consists of items in 4 EB dimensions, namely: *Certainty* (whether knowledge is absolute), *Source of knowledge* (whether one believes in authority of knowledge), *Justification* (whether one justifies knowledge rather than simply accepts it as it is), and *Attainment of truth* (whether one would like to inquire about the truth).

A number of learning theorists advocated that epistemological development and learning which are important goals of education can be influenced by the epistemological beliefs held by individuals (Ryan, 1984; Schommer, 1990; Schommer, Crouse, & Rhodes, 1992). Conventional researchers focusing on the technical aspects of engineering began to quest about the nature of engineering knowledge (e.g., Irvine, Chin, & Frincke, 1998; Matt, 2002). It is within the interests of multiple disciplines to understand the epistemology of engineering learning, and how it is related to and can be fostered in online social environments. So far, the study of EB in technology-enhanced learning in higher education is limited.

2.4. Social network analysis

Most of the previous gender studies related to technology usage were based on linear statistical analyses on questionnaire responses and usage frequencies. However, a few studies adopted social network analysis (SNA) to compare gender differences in relation to social structures, such as the works by Igarashi, Takai, and Yoshida (2005) and Badar, Hite, and Badir (2013).

SNA (Wasserman & Faust, 1994) is originated from sociology research. In SNA, degree represents the sum of all other actors who are directly connected to the actor in concern. In other words, degree signifies activity or popularity of a particular participant in the social network. In particular, for directed relationships (such as those in the current study), *in-degree* measures the number of ties that points toward the actor in concern; and *out-degree* measures the number of ties that the actor in concern points toward. *Closeness* represents the mean of the geodesic distances between some particular actors and all other actors connected within. An actor is considered important if he/she is relatively close to all other actors. *Betweenness* is a measure of the number of times an actor connects pairs of other actors who otherwise would not be able to reach one another. It is a measure of the "potential of control". For example, an actor who is high in "betweenness" is able to act as a gate keeper controlling the flow of resources (e.g. information, money and power) between a pair of actors with whom the others that he or she is connected.

In recent years, SNA is becoming a popular methodology in analyzing network structures in various domains, as it simultaneously possesses two significant features: *network analysis* and *quantitative analysis*. As an emerging approach to analyze collaboration and human user interaction, SNA has been used in academic co-authorships (Barabási et al., 2002) and citation networks, enterprise network mining (Lin, Wu, Wen, & Tong, 2012) and crowd behaviors over OSNs (Kwak, Lee, Park, & Moon, 2010). Most studies focus on the behaviors of collective individuals, relatively few tap into the populations' beliefs and cognitive aspects. One of the few examples includes the

study on cognitive styles, linguistic behavior, and group structures in self-organized online discussions (Vercellone- Smith, Jablokowa, & Friedel, 2012).

2.5. The current study

As of today, female is still underrepresented within the engineering community (NACME, 2011). Together with the contexts reviewed above, we are motivated to conduct a study to investigate gender differences in OSNs as a socio-technical environment for collaborative learning. Methodologically speaking, we put forward an SNA with the time dimension and with additional considerations of actors' attributes including their background and psychometric measurements. Nodes on our sociogram are not only vertexes but people with their own beliefs, cognition, and doxastic attitude (doxastic is a term used in philosophy which refers to beliefs and opinions (Blackburn, 2008)). In particular, we adopt mixed methods of longitudinal SNA followed by a quantitative survey to explore gender differences in OSN beliefs as well as behaviors.

The current study is guided by the following research questions:

1. What are female and male engineering postgraduates' beliefs related to collaborative learning, such as collaboration and the nature of knowledge and knowing, before and after they engaged in collaborative learning through blogging?
2. Are there any differences in beliefs gains in collaboration and knowledge by participants' gender?
3. How do female and male engineering postgraduates participate in OSNs respectively when they are engaged in collaborative learning?

3. Method

3.1. Participants

The participants include 53 engineering postgraduate students (12 females, 41 males), who were studying in a course offered by a Master of Science programme in the information engineering discipline at a university in Hong Kong.

3.2. Procedures

Participants were required to compose reflective journal in the form of blog posts. In addition, they were also encouraged to comment on posts written by their peers. As a result, the participants were engaged in a blogging community (over *Blogger.com* offered by Google) that aims at collaborative learning and knowledge sharing in engineering subject. The participating bloggers co-constructed their understanding of key themes related to information engineering by composing blog posts collaboratively and interacting with and responding to one another's posts through comments and replies. Following 4 months of intensive online interaction, a blogging community with a total number of 53 blogs, 212 posts and 1,144 comments had been developed. Fig. 1 shows the sociogram emerged in 8 time-intervals with each spanning approximately 2 weeks.

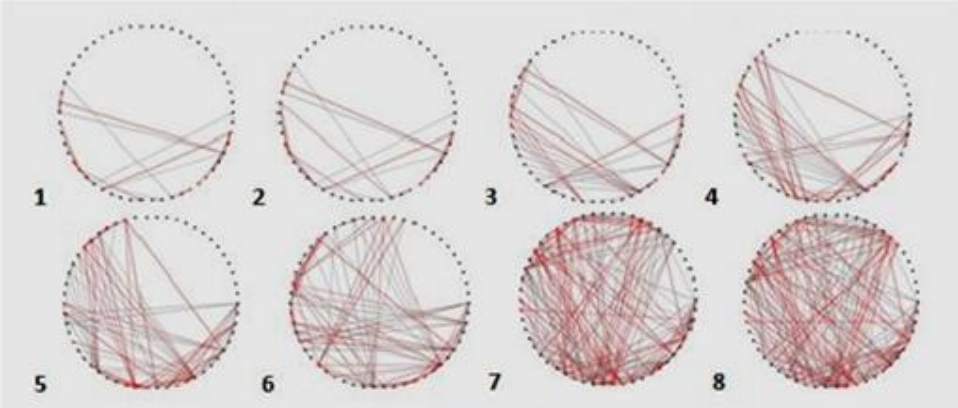


Fig.1. Evolution of the engineering postgraduate students' OSN (a blog community for collaborative learning). Red links indicate connection involving female participants.

3.3. Measures

Participants' beliefs were measured by 5 scales: *Collaboration* adopted from the Collaborative Knowledge Building (CKB) Questionnaire developed by Chan and Chan (2011) and measured collaboration and knowledge building; *Certainty of knowledge*, *Justification, Source of knowledge*, and *Attainment of truth* adopted from Hofer's (2000) epistemological beliefs (EB) measurement. Participants' responses to the items were represented using a 5-point Likert scale, with 1 being "strongly disagree" and 5 being "strongly agree". Reliability test, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted to ensure reliability and validity. Items with factor loadings less than .50 were excluded from the analysis. Factor loadings and Cronbach's alpha values of the scales are given in Table 1.

Besides, an 8-interval longitudinal SNA, each interval spans approximately 2 weeks, were conducted to study the evolution of the underlying social network resulted in the blogging community. The current study adopts 4 SNA indexes in measuring participants' social network behaviors, namely *in-degree, out-degree, closeness centrality, and betweenness centrality*.

3.4. Data analysis

Female and male participants' beliefs before and after OSN participation were compared by analyses of covariance (ANCOVAs) concerned with the pretest and posttest measurements of the CKB and EB scales. The SNA metrics were downloaded from *NodeXL* (http://nodexl.codeplex.com/), an open-source template for exploring network graphs such as sociograms. In our analysis, a directed tie from node A to node B corresponds to a comment provided by participant A to a blog post published by participant B.

Table 1
Factor loadings and reliability of scales

	Factor loading	Cronbach's α
Collaboration and Knowledge Building		
(1 = "strongly disagree"; 5 = "strongly agree")		.85
We work on improving our ideas continually during the process of inquiry.	.65	
Our views and knowledge broaden through working with others.	.63	
Ideas from different members are synthesized into new knowledge.	.63	
Class members pose different ideas with diverse perspectives.	.68	
Goal setting and planning for our progress is important.	.58	
We reflect on and assess the progress of our understanding continually.	.65	
Different groups can benefit each other and make progress together.	.76	
Different sources of reference information are examined for building knowledge.	.59	
The knowledge we work on is relevant to real-life problems.	.68	
Our ideas and knowledge are relevant within and outside the school context.	.63	
Certainty of Knowledge		
(1 = "strongly disagree"; 5 = "strongly agree")		.88
Knowledge does not changes even when experts gather more information.	.82	
All experts understand knowledge in the same way.	.82	
Absolute answers are unchanging.	.51	
Most questions have only one right answer.	.73	
The underlying principles are unchanging.	.74	
All experts would come up with the same answers to questions.	.74	
It is not good to question the ideas presented by experts.	.67	
Most of what is true is already known.	.83	
Justification		
(1 = "strongly disagree"; 5 = "strongly agree")		.70
First-hand experience is the best way of knowing something.	.78	
I am more likely to accept the ideas of someone with firsthand experience than experts.	.82	
Correct answers are more a matter of personal opinion than fact.	.74	
Source of Knowledge		
(1 = "strongly disagree"; 5 = "strongly agree")		.73
You just have to accept answers from the experts, even if you do not understand them.	.76	
If my personal experience conflicts with ideas of the expert, the expert is probably right.	.84	
I am most confident that I know something when I know what the experts think.	.83	
Attainment of Truth		
(1 = "strongly disagree"; 5 = "strongly agree")		.79
Experts in this field can ultimately get to the truth.	.86	
If experts try hard enough, they can find the answers to almost anything.	.75	

4. Results

4.1. Descriptive statistics for OSN beliefs

Descriptive statistics (means and standard deviations) of participating engineering postgraduate students' beliefs about OSNs are displayed in Table 2 below.

Table 2
Means and standard deviations of scales

		Pretest			Posttest		
Scale	Max	female (n=12)	male (n =41)	total (N=53)	female (n=12)	male (n =41)	total (N=53)
Collaboration	5.0	2.02 (0.40)	2.06 (0.38)	2.05 (0.38)	2.94 (0.22)	2.71 (0.28)	2.76 (0.29)
Certainty	5.0	2.29 (0.63)	2.53 (0.77)	2.48 (0.74)	1.93 (0.49)	2.19 (0.73)	2.13 (0.69)
Justification	5.0	3.19 (0.60)	3.25 (0.51)	3.24 (0.52)	3.42 (0.70)	3.37 (0.65)	3.38 (0.65)
Source of knowledge	5.0	3.47 (0.54)	3.32 (0.67)	3.35 (0.64)	3.22 (0.85)	3.06 (0.73)	3.10 (0.75)
Attainment of Truth	5.0	3.17 (0.87)	3.03 (0.92)	3.06 (0.90)	2.94 (1.24)	2.89 (0.91)	2.90 (0.97)

Paired-sample *t-tests* were performed to determine if the posttest scale scores (i.e., after the OSN participation) significantly differ from the pretest scores. Results for the female group, male group, and the overall participants are displayed in Table 3 below.

Table 3
Paired-sample t-tests of pretest and posttest scores

	Female (n = 12)			Male (n = 41)			Overall (N = 53)		
Source	*df*	*t*	*p*	*df*	*t*	*p*	*df*	*t*	*p*
Collaboration	11	7.20***	.00	41	8.42***	.00	52	7.29***	.00
Certainty	11	2.88*	.02	41	3.33**	.00	52	4.1***	.00
Justification	11	1.46	.18	41	1.41	.17	52	1.92	.06
Source of knowledge	11	1.55	.16	41	3.33**	.00	52	3.71**	.00
Attainment of Truth	11	1.00	.35	41	1.25	.22	52	1.59	.12

Note: ***p <.001, ** p <.01, *p <.05

4.2. Longitudinal SNA

The four SNA metrics (in-degree, out-degree, closeness centrality, and betweenness centrality) on the social network evolved within the participants' blogging community were obtained in 8 time intervals. The measures have been normalized to values between 0 and 1. Fig. 2a to 2d depict the development of the in-degree, out-degree, closeness centrality, and betweenness centrality grouped by gender, respectively.

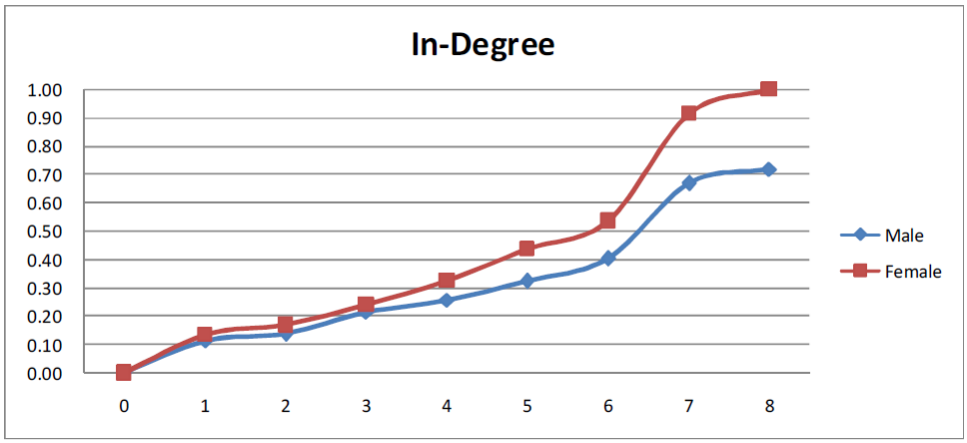


Fig. 2a.The development of in-degree throughtime by gender

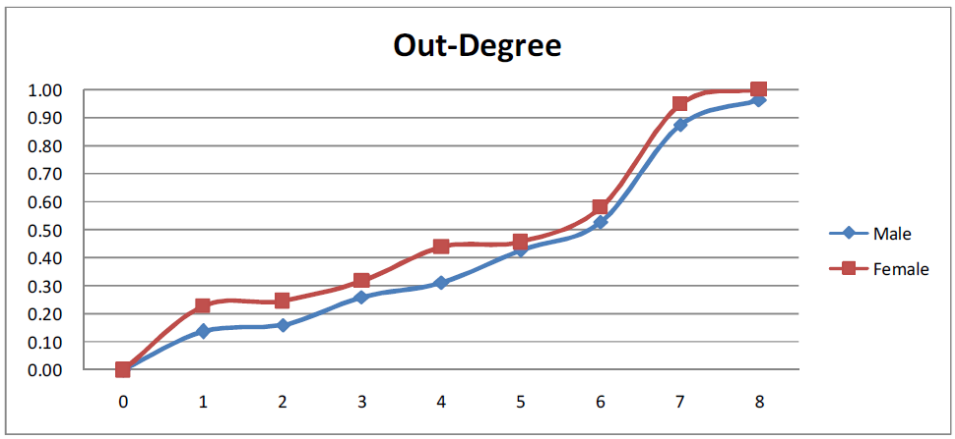


Fig. 2b.The development of out-degree through time by gender

Fig. 2c.The development of closeness through time by gender

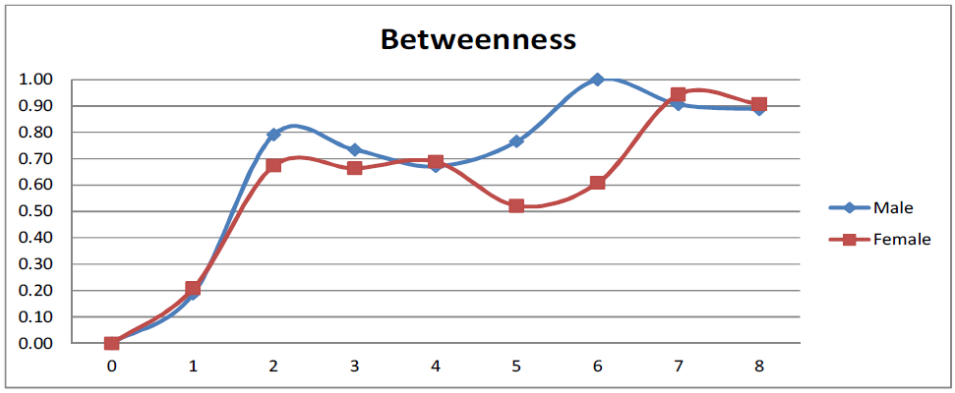


Fig. 2d.The development of betweenness through time by gender

4.3. Gender differences in OSN beliefs and behaviors

ANCOVAs were conducted to investigate whether gender group differences may exist regarding participants' pretest and posttest collaboration beliefs and epistemological beliefs. Results show significant differences in *Source of knowledge*, $F(1, 51) = 5.36$. $p < .05$, $\eta 2 = .13$, favoring female ($M = 4.32$, $SD = 0.48$) over males ($M = 4.20$, $SD = 0.34$). There was no significant differences in the four dimensions in epistemological beliefs, namely *Certainty* ($p > .05$), *Justification* ($p > .05$), *Source of knowledge* ($p > .05$), and *Attainment of truth* ($p > .05$).

With reference to the metrics corresponding to the longitudinal development of the OSN emerged (Fig. 2a - 2d), one can observe the following trends: (1) female participants are likely to be associated with greater in-degree, out-degree, and closeness centrality than their male counterparts do at all times, and (2) the blog behavior of male participants' reveals greater betweenness centrality than their female counterparts do most of the time.

5. Discussions

5.1. Engineering postgraduates' beliefs gains

Results generated from the statistical analyses of the current study indicate significant gains in participants' beliefs concerning collaboration, certainty, and source of knowledge respectively. In particular, participants responded more positive attitude towards collaboration in aspects such as epistemic agency, diversity and improvement of ideas, and symmetrical advancement of knowledge. In terms of certainty of knowledge, participants viewed knowledge as less certain and less absolute after their OSN participation. As regard the source of knowledge, participants believed that knowledge came from diverse sources rather than from the authorities. Following from these, more advanced epistemological beliefs have been exhibited by the participants as a result of their engagement in OSN interaction. However, there were no statistically significant gains in justification of knowledge nor the attainment of truth, indicating that participants' belief enhancement in these two epistemological dimensions was not salient among the participants in the current study.

A closer look at the components that make up the CKB scale enables one to pay attention to the socio-cognitive as well as technological dynamics in the design and implementation of OSN applications. Law (2005) categorized Scardamalia's (2002) knowledge building principles, as well as Gunawardena, Lowe, and Anderson (1997) phase of knowledge co-construction, Newman, Johnson, Webb, and Cochrane (1997) indicators for critical thinking and Soller, Goodman, Linton, and Gaimari (1998) characteristics of collaborative learning into four dimensions, which she called the communal learning outcomes in knowledge building. Law's categorization of knowledge building outcomes (Law, 2005, p.375) provides some helpful suggestions for OSN designers, especially those who are implementing OSN for educational purposes such as e-learning in higher education:

- **A social dynamic conducive to sharing and open exploration of ideas**. This dimension is related to four of the knowledge building principles, namely community knowledge, collective responsibility, democratizing knowledge and idea diversity. According to Law (2005), these components can be interpreted as "an affirmation of the importance of a conducive social dynamic as a pre-requisite for further knowledge building advances" (p.375).
- **Progressive inquiry orientation**. According to Law's categorization (2005), this dimension involves four of the knowledge building principles, namely epistemic agency, knowledge building discourse, improvable ideas and constructive use of authoritative sources; and it is related to a critical exploration of ideas and progressive inquiry, and also requires the participants of a knowledge building community to set the advancement of knowledge as their explicit goal (i.e., the "epistemic agency").
- **Socio-metacognitive orientation of the community**. This dimension involves four knowledge building principles, namely real ideas, authentic problems, rise above, embedded and transformative assessment. This specification demands the community members to engage metacognitively in knowledge advancements for effective collaborative learning. It also requires the members to formulate higher level conceptualizations from the discourses, and to engage in self-assessments continuously so as to sustain a community for knowledge building.
- **A collective habit of mind.** This dimension comprises two knowledge building principles, namely pervasive knowledge building and symmetric knowledge advancement. It is a status in which the community members have developed a community-level practices in which the acts of knowledge building have already been internalized as a "mental habit".

Acknowledged from the above dimensions which cover wider perspectives including different phases of knowledge co-construction (Gunawardena, Lowe, & Anderson, 1997), indicators for critical thinking (Newman, Johnson, Webb, & Cochrane, 1997) and characteristics of collaborative learning (Soller, Goodman, Linton, & Gaimari, 1998), one is better informed when conducting collaborative learning on SNS such as those who participated in blogging (as implemented in the current study), and the design of socio-technological environments for cognitive scaffold.

5.2. Gender differences in OSN beliefs gains

Results obtained from the current study indicate significant differences between female and male engineers' beliefs in collaboration, in which female engineers have significantly stronger beliefs gains about collaboration after participating in online learning communities than their male participants do. However, there were no statistically significant gender differences in gains in the 4 dimensions of epistemological beliefs (i.e., certainty, justification, source of knowledge, and attainment of truth).

According to the previous results obtained by Chan and Chan (2011), gender by grade effects existed in students' beliefs in collaboration in the sense that male students obtained higher scores than female students did among junior but not senior grader. The current study further extends the developmental trajectory from the Chan & Chan's results and indicates that female postgraduate students show a stronger beliefs gain in collaboration than their male counterparts do. For epistemological beliefs, the current results align with those obtained by Conley, Pintrich, Vekiri, and Harrison (2004) in that no significant differences in epistemological belief gains by gender were found among elementary science students. Our results also align with those obtained by Buehl, Alexander, and Murphy (2002) on undergraduate students, in that no significant main effect for gender was found involving epistemological belief measures.

Combining the findings obtained from the current as well as the previous studies, they support the argument that gender differences exist in belief gains related to social aspects (i.e., collaboration) but not individual's epistemic aspects (i.e., epistemological beliefs or personal epistemology (Hofer & Pintrich, 2002)).

5.3. Gender differences in OSN behaviors

The current study investigated gender differences in collaborative learning through OSN behaviors and obtained the longitudinal SNA metrics (in-degree, out-degree, closeness centrality, and betweenness centrality) from the emergent social network. Similar to the previous researchers' findings, such as that by Joinson (2008) and Kimbrough, Guadagno, Muscanell, and Dill (2013), females participated more actively than males did in terms of social interaction and communication. This has been reflected in a consistently higher in-degree as well as out-degree demonstrated by the female participants than their male counterparts. Furthermore, as indicated from a consistently higher closeness centrality, female participants could easily get information without relying on many others (according to the conceptual meaning of closeness in social networks (Wasserman & Faust, 1994). The above aspects are also partially consistent with the earlier findings by Barrett and Lally (1999), who suggested that the roles played by male and female postgraduate students in online learning environments are notably different. For example, female students acknowledged the contributions made by other students significantly more often than their male students did, and they displayed more "care" than the male students did when incorporating information and ideas from previous messages in their replies.

One of a novel finding obtained in the current study is that male participants were the potential controllers of information flow in an OSN, as indicated by the high betweenness centrality measures most of the time throughout the longitudinal study. According to Hansen, Shneiderman, and Smith (2011), betweenness can be thought of as a kind of "bridge" score which is a measure of disruption caused by removing a particular actor to the connection between participants within the social network (p.41).

6. Conclusion

The findings of this study presented an investigation of gender differences in OSN beliefs and behaviors. In particular, a longitudinal study has been conducted with engineering postgraduate students' beliefs and behaviors of collaborative learning in a blogging community as an online social environment. A number of empirical research evidence has been obtained to support the views concerning the social roles played by female and male members within an OSN. The current study further confirmed the participants' beliefs gains in conducting collaborative learning over OSN (e.g., an online platform for blogging).

The following research topics are identified from the current study for future explorations:

- Expanding the scale of analysis by obtaining empirical data from more engineering students as well as students from other disciplines
- Investigating the relationship between participants' beliefs and their behaviors in online learning communities
- Performing qualitative content and discourse analysis on participants' blog posts and comments in relation to the results concerned with their beliefs and behaviours

To conclude, a fundamental principle of human communication is that the exchange of ideas occurs most frequently between individuals who are alike, or homophonous (Rogers, 1995). Although female and male participants behave differently within OSNs, as indicated in the results of the current study, they co-exist collectively at a community level which should not or cannot be fragmented into two isolated gender groups. The emergent social network though the blogging community under investigation, as well as the overall beliefs gains amongst the participants in collaboration and a number of dimensions including epistemological beliefs, indicate productive social interaction and epistemological advancement among all participants. All in all, empirical findings obtained from the current study provide important insights into the design and adoption of technology for higher education, adult learning and human performance from a gender perspective.

References

Antonucci, T. C., & Akiyama, H. (1987). An examination of sex differences in social support among older men and women. *Sex Roles, 17*, 737–749.

Badar, K., Hite, J. H., & Badir, Y. (2013). Examining the relationship of co-authorship network centrality and gender on academic research performance: The case of chemistry researchers in Pakistan. *Scientometrics, 94*(2), 755–775.

Barabási, A. L., Jeong, H., Néda, Z., Ravasz, E., Schubert, A., & Vicsek, T. (2002). Evolution of the social network of scientific collaboration. *Physica A, 311*(3–4), 590–614.

Barrett, E., & Lally, V. (1999). Gender differences in an on-line learning environment. *Journal of Computer Assisted Learning, 15*, 48–60.

Blackburn, S. (2008). *The Oxford dictionary of philosophy* (2nd, ed.). New York: Oxford University Press.

Blum, K. D. (1999). Gender differences in asynchronous learning in higher education: learning styles, participation barriers and communication patterns. *Journal of Asynchronous Learning Networks, 3*, 46–66.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology, 27*, 415–449.

Chan, C. K. K., & Chan, Y.-Y. (2011). Student views of collaboration and online participation in Knowledge Forum. *Computers & Education, 57*, 1445–1457.

Chan, C. K. K., Law, N., & van Aalst, J. (2008). *Developing principle-based understanding for knowledge building in a teacher community*. Paper presented at the Annual Meeting of the American Educational Research Association, New York.

Chinn, C., Buckland, L., & Samarapungavan, A. (2011). Expanding the dimensions of epistemic cognition: arguments from philosophy and psychology. *Educational Psychologist, 46*, 141–167.

Conley, A. M., Pintrich, P. R., Vekiri, J., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology, 29*, 186–204.

Fu, E. S. J., Yang, S. J. H., & Huang, J. J. S. (2012). A snapshot of students' blogging profiles in Taiwan: From the viewpoint of knowledge sharing. *Knowledge Management & E-Learning, 4*(1), 7–15.

Griffiths, D. (1985). The exclusion of women from technology. In W. Faulkner & E. Arnold (eds), Smothered by Invention (pp. 51–71). London: Pluto Press.

Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of 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, 17*(4), 397–431.

Hansen, D. L., Shneiderman, B., & Smith, M. A. (2011). *Analyzing social media networks with NodeXL: Insights from a connected world*. Burlington, MA: Morgan Kaufmann.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology, 25*, 378–405.

Hofer, B. K., & Pintrich, P. R. (Eds.). (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Erlbaum.

Igarashi, T., Takai, J., & Yoshida, T. (2005). Gender differences in social network development via mobile phone text messages: A longitudinal study. *Journal of Social and Personal Relationships, 22*(5), 691–713.

International Telecommunication Union (ITU). (2012). *ICT statistics by gender*. Retrieved from http://www.itu.int/ITUD/ict/statistics/Gender/index.html

Irvine, C. E., Chin, S.-K., & Frincke, D. (1998). Integrating security into the curriculum. *Computer, 31*(12), 25–30.

Joinson, A. N. (2008). 'Looking at', 'looking up' or 'keeping up with' people?: motives and uses of facebook. In *Proceedings of 26th International Conference on Human-Computer Interaction* (CHI 2008) (pp. 1149–1158).

Kimbrough, A. M., Guadagno, R. E., Muscanell, N. L., & Dill, J. (2013). Gender differences in mediated communication: Women connect more than do men. *Computers in Human Behavior, 29*, 869–900.

Kwak, H., Lee, C., Park, H., & Moon, S. (2010). What is Twitter, a social network or a news media? In *Proceedings of the 19th International Conference on World Wide*

Web. Raleigh, North Carolina, USA.
Law, N. (2005). Assessing learning outcomes in CSCL settings. In T. Koschmann, T. W. Chan, & D. D. Suthers (Eds.). *Computer Supported Collaborative Learning* (pp.373–377). New Jersey: Lawrence Erlbaum Associates, Inc.,.
Li, S., Chan, R. Y.-Y., Jong, M., Huang, J., & Yu, P. (2013). *Students' epistemic cognition in online social networks*. Paper presented in 19th Global Chinese Conference in Computers in Education (GCCCE 2013). Beijing.
Lin, C. Y., Wu, L., Wen, Z., & Tong, H. (2012). Social network analysis in enterprise. *Proceedings of the IEEE, 100*(9) (pp. 2759–2776).
Matt, B. (2002). Computer security education: Training, scholarship, and research. *Computer, 35*(4), 30–32.
National Academies. (2012). *Transferable knowledge and skills key to success in education and work; Report calls for efforts to incorporate 'Deeper Learning' Into curriculum*. Retrieved from http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=13398
National Action Council for Minorities in Engineering (NACME). (2011). *2011 NACME data book: A comprehensive analysis of the "New" American dilemma*. National Action Council for Minorities in Engineering, Inc.
Newman, D. R., Johnson, C., Webb, B., & Cochrane, C. (1997). Evaluating the quality of learning in computer supported co-operative learning. *Journal of the American Society for Information Science, 48*(6), 484–495.
Rogers, E. M. (1995). *Diffusion of innovations*. New York: The Free Press.
Ryan, M. P. (1984). Monitoring text comprehension: Individual differences in epistemological standards. *Journal of Educational Psychology, 76*(2), 248–258.
Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal Education in a Knowledge Society* (pp. 67–98). Chicago, IL: Open Court.
Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *The Journal of the Learning Sciences, 3*(3), 265–283.
Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 97–119). New York: Cambridge University Press.
Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology, 82*, 498–504.
Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology, 82*, 435–443.
Soller, A., Goodman, B., Linton, F., & Gaimari, R. (1998). *Promoting effective peer interaction in an intelligent collaborative learning environment*. Paper presented at the Fourth International Conference on Intelligent Tutoring Systems (ITS '98), San Antonio, TX.
Sørensen, K. H. (1992). Towards a feminized technology? Gendered values in the construction of technology. *Social Studies of Science, 22*(1), 5–31.
Spender, D. (1995). *Nattering on the net: Women power and cyberspace*. Melbourne: Spinifex Press.
Stahl, G., Koschmann, T. D., & Suthers, D. (2006). Computer-supported collaborative learning: an historical perspective. In R. K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 409–426). New York: Cambridge University Press.
Vercellone-Smith, P., Jablokowa, K., & Friedel, C. (2012). Characterizing communication networks in a web-based classroom: Cognitive styles and linguistic behavior of self-organizing groups in online discussions. *Computers & Education, 59*,

222–235.

Wang, L.-C., & Chen, M.-P. (2012). The effects of learning style and gender consciousness on novices' learning from playing educational games. *Knowledge Management & E-Learning, 4*(1), 63–77.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Method and analysis*. Cambridge University Press.

Zagzebski, L. (2009). *On epistemology*. Belmont, Calif.: Wadsworth.

Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for collective cognitive responsibility in knowledge-building communities. *The Journal of the Learning Sciences, 18*(1), 7–44.