Social Epistemic Cognition and Engineering Students' Collaborative Learning in Emerging Areas

An Implementation Case Study in a Course for Social Networking

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***Abstract*—Social epistemic cognition (SEC) is a recent construct established in the human-computer interaction (HCI) research community; which concerns an individual's knowledge-related cognitive processes in a social environment. Its related theory states that SEC can be mediated by online interactions. This paper reports how the SEC and related theoretical frameworks have been applied in an engineering education context. It presents the course design, implementation, and a number of direct evidences collected from the course implementation throughout 2012 to 2015. In particular, research data and learning evidences (obtained from questionnaires, student interviews, social network analysis and students' course performance scores) are presented to confirm the positive relationship between SEC and engineering students' academic performance. The author hopes to engender further discussions on how SEC can be conceptualized into effective engineering learning, teaching, and assessment.**

Keywords—Social Epistemic Cognition; Collaborative Knowledge Building; Social Network Analysis; Engineering Learning; Learning Sciences

I. Introduction

Social interactions play a critical role in knowledge advancement. Perspectives from learning sciences views human learning as a cognitive process which involves the social interactions between the learner, the social environment in which learning occurs, and the learning activity in which the learner participates [1]. The advent of social media and online social media has revolutionized the way how people interact. Nowadays, learners can participate in various online social networking venues to acquire and disseminate knowledge. They can also construct new knowledge collaboratively through online discussion and argumentation [2]-[4]. Examples include forum discussions over questions and answers sites such as Quora.com and Massive Open Online Courses (MOOCs) such as Coursera, Khan Academy, and Edx.

Social epistemic cognition (SEC) is a recent framework developed in the field of human-computer interaction (HCI); which refers to human individual's socio-cognitive processes in epistemic (i.e. knowledge-related) matters and activities such as the acquisition of new knowledge [5]. Its related theory states that human SEC can be mediated through online interactions (p. 3296). Studies related to SEC investigate human individuals' knowledge-driven beliefs and behaviors in social environments, so as to inform about the design of user experience for collaboration and epistemic purposes [6]-[7]. Various educational research works have provided empirical evidences to conclude the prediction of human learning by epistemic beliefs [8]-[10]. SEC, having a tripartite root in social cognition, epistemic cognition, and social epistemology, further explains how learners' beliefs associated to the epistemic matters can be promoted through social interactions especially when these interactions are mediated through online environments.

A. Motivation and Related Works

SEC is a theoretical framework established only very recently. Nevertheless, it is rooted in a solid foundation in philosophical epistemology and cognitive psychology; and is practically related to knowledge building [2] and computer-supported collaborative learning (CSCL) [3]-[4]. There exist a few works on knowledge building and CSCL (including those facilitated by Web 2.0 environments) in engineering education contexts. For example, Gillet *et al*. deployed a collaborative web-based experimentation environment to facilitate engineering students' learning and knowledge building through online hands-on laboratories in automatic control and fluid mechanics [11]. Parker and Chao discussed the potential of adopting Wiki as a teaching tool for software engineering learning [12]. Mats and Asa also discussed the use of collaborative technologies in engineering education, and reported an implementation case in collaborative learning between engineering students in the US and Sweden [13].

There are also an increasing number of online collaborative learning opportunities in engineering education contexts through MOOCs; which implies the potential impact and growing importance of SEC in engineering teaching and learning. For example, Breslow *et al.* studied how MOOC students learned "Circuits and Electronics" (the first MOOC developed by edX) via video lectures, interactive problems, online laboratories, and online discussion [14]. However, there are only very few engineering education studies which focus on students' cognition when situated in online social learning environments, with a few exceptions including [15] and [16]. The current work is motivated by the growing popularity of online learning in engineering education, such as MOOC, flipped classrooms, or a hybrid implementation between online learning and traditional lectures; and the need to understand engineering students' socio-cognitive processes in online learning environments so as to design pedagogical aids to facilitate their learning.

B. *Our Contributions and Significance*

This paper presents an implementation case study; in which pedagogical strategies derived from the theoretical framework of SEC and collaborative knowledge building has been applied iteratively in engineering education settings. In particular, it investigates engineering students' SEC and collaborative learning in a fast growing knowledge domain (online social networks and social media analytics). Below are the contributions to engineering education research and practice of the current work.

1. The first reported effort that designs, implements, and evaluates students' SEC in engineering education contexts.
2. Produces engineering education specific evidences by engaging engineering students in collaborative knowledge building over online learning comminutes.
3. Provides evidence-based suggestions to engineering and computing educators regarding the pedagogical strategies for enhancing engineering students' SEC.

Overall, the author hopes this work can engender further discussions on SEC and its implications to the practice of engineering and computing education and the design of effective learning environments.

II. THEORETICAL FRAMEWORKS

A. *Social Epistemic Cognition*

SEC is a recent theoretical construct in HCI established by Chan *et al.* [5] with its theory and the mediator role of online interactions proven by empirical evidences. SEC concerns about human cognitions and cognitive processes directed by epistemic aims and in social settings. SEC has a tripartite root in *social cognition* [17] – that connects externally observable behaviors to internal human beliefs, *epistemic cognition* [18], [19] – that connects subjective human internal attitudes to the objective nature of knowledge; and *social epistemology* [20], [21] – that manifests the social dimensions of knowledge and the epistemic nature of social interactions.

Core fields in philosophy examine how we know (epistemology) and how we experience (phenomenology). One view about the self in philosophy is that it is a conscious agent which can produce beliefs and knowledge by interacting with the external world through its cognitive faculties such as sense, memory, and imagination [22]. Developmental psychologists further differentiate epistemic cognition from cognition and metacognition [18]-[19]. Human individuals perceive through cognitive processing such as reading and listening; and exercise metacognition such as self-monitoring and self-regulating over these processes. They also engage in epistemic cognition – in which individuals reflect on knowledge-related matters such as the limits of their knowledge and the justification and criteria of knowing. A number of works in psychology and human development have provided empirical evidence to conclude that epistemic beliefs predict human learning and knowledge creation (see e.g., [9] for a collection of studies in the relationship between epistemic beliefs and student learning).

SEC extends the social dimension of epistemic cognition; and enables human's inner intentions and belief states associate to epistemic (i.e. knowledge-related) matters to be measured by externally observable social behaviors such as collaboration and scientific knowledge co-construction. Empirical evidence validated with statistical structural equation modeling has shown that human social epistemic cognition can be mediated through online interactions [5: 3294], which aligns to earlier results obtained by educational researchers (e.g., [23]). As inherited from Chinn *et al.*'s epistemic cognition framework [18], SEC also covers the five components below. Examples in engineering education context are also provided to illustrate the concepts.

1. **Social epistemic aims** – corresponds to the intentions (e.g., knowing together, seeking for common understanding, explaining things to the others, seeking for truth together) when a person engage in the cognitive processes within a social environment. For example, a student discusses the experiment data with his/her classmates in order to achieve a common understanding of the experimental results.
2. **Structure of social knowledge** – corresponds to a person's view about the representation and structural format of knowledge which is commonly shared within a social group. This element also intertwines with the person's ontological views about the knowledge domain. For example, whether a student views that knowledge commonly shared within an online learning community is simple or complex, probabilistic or deterministic, etc. and what does he/she think that knowledge in one domain (e.g., engineering) is connected to knowledge in another domain (e.g., psychology).
3. **Source and justification of social knowledge** – corresponds to the attitudes that a person take towards information exists in the social environment, e.g., to believe it or to have a skeptic doubt about it. It also involves a person's belief about the origin of the socially shared knowledge and his/her reasoning about such beliefs. For examples, when a student reads an article about a newly discovered security loophole from an online discussion forum, will he/she simply believe it or perform further inquires and examinations to verify the correctness and trustworthiness of that article.
4. **Social epistemic virtues** – regarding the kinds of intellectual virtues that a person demonstrates (e.g., seeking knowledge conscientiously and carefully; having the courage to point out misinformation) within a social group; and how he/she may response to dilemmas related to virtues, ethics, and professionalism in social situations. For example, when an engineering

student conducts a piece of research within an engineering research group, how would he/she uphold engineering ethics and intellectual virtues which might conflict to his/her rights (e.g., obtaining good grades or secure a job opportunity) in the situation.

5. **Processes of achieving social epistemic aims** – corresponds to the social processes (e.g., argumentation and collaboration with the others) a person may carry out in order to achieve the social epistemic aims and also the reliability of such processes. For example, the social processes that an engineering student undergoes with his/her teammates in performing a group project which aims at investigating a new topic in engineering.

Just as epistemic cognition is driven by epistemic aims, SEC is driven by social epistemic aims (e.g., to achieve common knowledge and shared understanding within a group); as well as epistemic aims that are achieve through social processes (e.g., to know by having argumentation with the others).

B. Collaborative Knowledge Building

Collaborative knowledge building (CKB) [2], [24] is the theoretical foundation that supports CSCL [23: 1456]. CKB emphasizes the collective cognitive responsibility and the engagement of learners in an online community in creating new shared knowledge with the mediation of online discourses. For example, an online learning environment can be designed according to the socio-cognitive and socio-technological dynamics to support common knowledge advancement amongst the participating members. By interacting over an online learning environment through synchronous or asynchronous discourses, a community of learners can co-construct knowledge that is commonly shared amongst the community members. For example, learners can post ideas, comments, and links to external references to co-construct explanations, conduct online argumentations, and reflect/revise their ideas. Eventually, the community knowledge is advanced.

Scardamalia [25] defined a set of twelve principles to characterize knowledge building. These principles are cohesive and intertwining which includes 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. These principles together portray collaboration as an activity that goes beyond the division of labor and emphasizes on collaborative learners' idea improvement and collective responsibility in common knowledge advancement. According to the research results from Chan and Chan [23], students' beliefs associate to collaborative knowledge building is predicted by and strongly related to their deep approach to learning; while the relationship between students' beliefs in collaborative knowledge building and a surface approach to learning is statistically insignificant. It should be noticed that students' approaches to learning correspond to their intentions, motivation, and strategies as they go about learning [26]. While students adopting a surface learning approach view learning as meeting requirements and tend to complete the assignments with minimum effort. On the contrary, students adopting a deep learning approach are motivated to learn intrinsically. They also aim at and are committed to understanding. Deep learning is therefore a more robust learning attitude for engineering students who need to master the foundational knowledge in science and mathematics to cope with opened, complex engineering problems in their future career [27].

C. Knowledge and Learning in Comtemporary Engineering Education

The Internet and social media have changed the way in which knowledge is distributed and acquired. In addition, today's society changes continuously, while engineering education used to followed changes in technology and society, it must response and adapt fast enough to stay technologically relevant [27]. Figure 1 is adapted from Palmer's work [28]. It depicts what we used to know about engineering knowledge and learning (left); and what engineering knowledge and learning can be within a collaborative learning community (right). Traditionally, engineering knowledge is known to be accessible by only a small number of experts such as engineering professors through their own studies, and be disseminated from the experts to the "novices" such as the engineering students. It is also believed that there exist barriers between knowledge and experts (e.g., the experts need to spend a huge amount of time in knowledge discovery) and experts and novices (e.g., the novices take time to learn what the experts teach about engineering knowledge). However, Palmer [28] and numerous researchers in knowledge building and CSCL (such as [3]-[4], [24]-[25]) have pointed out that knowledge and learning can be facilitated within a collaborative learning community in which experts and novices can access to a common body of knowledge and share with each other collaboratively.

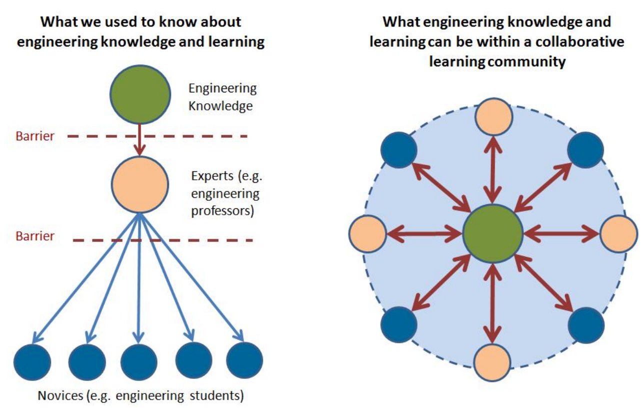

Fig. 1. Engineering knowledge and learning in traditional expert and novice model (left) and within a collaborative learning community (right). Pictures adapted from Palmer's work [28].

The paper author further derives Figure 2 (on next page) which shows what engineering knowledge and learning can be within an online community of engineering learners. It can be shown that the online social environment hosts the social interactions amongst experts and novices (e.g., an online discussion) and further mediates the interactions between experts and novices through online information objects (e.g., an engineering professional publishes a piece of technological blog post and is commented by an engineering student).

It should be emphasized that the processes illustrated in Figure 1 and 2 only correspond to the way in which engineering knowledge can be disseminated and acquired. It still requires the learners to perform further cognitive processing over the information objects which are the representation of engineering knowledge (e.g., a MOOC video about electric circuits) in order to truly understand the subject. SEC is involved in the interaction between a learner and a knowledge object.

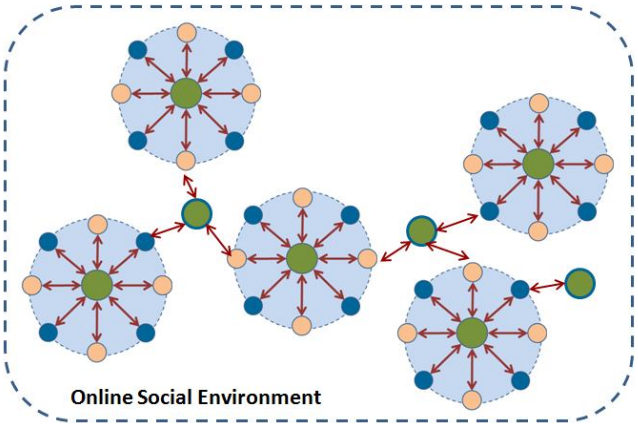

Fig. 2. Engineering knowledge and learning through collaboborative learning sustained by an online social environment. Picture derived by the paper author from Palmer's work [28].

D. The Current Study: SEC in Engineering Students' Collaborative Learning

In this work, the author aims to study SEC in engineering students' collaborative learning of emerging concepts in engineering. The study is guided by three research questions.

1. (RQ1): How is engineering students' SEC related to collaborative knowledge building?
2. (RQ2): What are the socio-dynamic processes involved when engineering students go about collaborative learning and exercising their SEC?
3. (RQ3): What direct evidences on SEC can be obtained in an engineering teaching and learning setting that provide insights to effective pedagogical design which can promote engineering students' SEC and academic performance?

III. Teaching and Learning Context of the Current Study

A. The Implementation Context

The author is an engineering faculty member in the information engineering discipline at a university in Hong Kong. She has an interdisciplinary background in engineering, education psychology, and learning sciences. She is the course designer and instructor of a postgraduate course titled "Social Networking"; the course in which the current study is conducted. The course was first launched in the Spring semester of 2012, and has also been offered in the Fall semesters in 2012, 2013, and 2015 respectively. It aims to provide a holistic overview on both technology and humanity aspects of the emerging field of online social networks. There is no single textbook suitable for the course, because it covers a number of emerging and evolving areas, such as those in communication and online social behaviours, psychology and cognition in online social networks, and social network analysis. The students were major in information engineering, electronic engineering, or computer science.

B. The Course Syllabus

The course includes 12 lectures. It is interdisciplinary by nature and builds on knowledge across multiple fields such as communication engineering, psychology, sociology, and network science. Its syllabus is provided in table I below:

TABLE I. Syllabus of the Course

Lecture	Topic(s)
1	Social Networking: An Overview I
2	Social Networking: An Overview II
3	Psychology and Cognition in Online Social Networks I
4	Psychology and Cognition in Online Social Networks II
5	Communication and Online Social Behaviours I
6	Communication and Online Social Behaviours II
7	Social Network Analysis I
8	Social Network Analysis II
9	Social Network Analysis III
10	Social Network Analysis in Practice
11	Social Semantic Web and Web 3.0
12	Course Conclusion

The author also taught in another related course, "Social Media Analytics", which applied mathematical and computational techniques (e.g., content analysis, Natural Language Processing, and sentiment analysis) to analyze social media contents. Students were encouraged to take both courses to reinforce their learning in the emerging area of online social networks and social media. However, this paper focuses on the implementation of the course "Social Networking".

C. Assessment for Learning and the Assessment Scheme

The author adopts the assessment for learning approach [29] in her course teaching with carefully designed assessment items (table II) to enhance students' motivation to learn.

TABLE II. Assessment Scheme of the Course

Assessment Item	Percentage
Individual assignment (blog writing, at least 4 posts)	28%
Participation (giving comments in peer blog posts)	12%
Group presentation (collaborative project and presentation)	20%
Final Examination	40%

Two of the assessment items, namely the individual assignment and participation are designed to enable the students to directly experience and reflect upon various novel concepts introduced in the course. In particular, the author established and facilitated online learning communities comprised of the whole class in every course implementation. Every participating student was required to establish a blog and to interact through blog posting and commenting. During the class, the author introduced and discussed the concepts by relating the ideas to students' own blogging experience. Besides blog posting and commenting, students are also required to conduct a group project and attend a final examination. The final examination consists of question items in three types, namely: conceptual questions, computational questions, and mixed questions (that involve both conceptual and computational knowledge related to the course).

IV. METHOD

A. Participants

Participants were 211 engineering students enrolled in the course IEMS 5720 Social Networking offered by Department of Information Engineering, The Chinese University of Hong Kong. They were divided into 4 cohorts according to the year in which the course were implemented (N = 54, 44, 48 and 65 for 2013 spring semester, 2013 fall semester, 2014 fall semester, and 2015 fall semester, respectively).

B. Procedures

The series of studies took place in the context of the course. Participating students attended face-to-face lectures, and engaged in a cohort-based online learning community (in form of a bloggers' community) where they published blog posts to share their reflection, findings, or self-reported reference materials (e.g., a YouTube video) related to the course contents that they have learned in the lecture. They also interact with each other by writing comments to peers' blog posts and replying to the comments. The students also participated in the final examination at the end of the semester. 4 online learning communities with a total number of 211 blogs have been established by the participating students over the implementation period from 2012 to 2015.

C. Measures

As an implementation case study, the author collected a number of evidences related to course teaching and learning. This includes:

1. questionnaire on social epistemic cognition;
2. questionnaire on collaborative knowledge building;
3. patterns of social interactions in the social network resulted from the online learning communities;
4. student interviews; and
5. students' academic performance in the course.

1) Questionnaire on Social Epistemic Cognition: This study employed the Epistemic Cognition Instrument (ECI) [5] to access students' SEC. The questionnaire consists of 32 items in 6-point Likert scale that corresponded to the five SEC components, namely social epistemic aims (6 items), structure of social knowledge (6 items), source and justification of social knowledge (7 items), social epistemic virtues (7 items), and processes of achieving social epistemic aims (6 items).

2) Questionnaire on Collaborative Knowledge Building: The 12-item collaborative knowledge building (CKB) questionnaire developed by Chan and Chan [23] was employed to access participating students' beliefs associated to collaborative knowledge building. The questionaire items were in 6-point Likert scale. These 12 items together corresponded to the cohesive twelve principles on knoweldge building proposed by Scardamalia [25].

3) Social Evidences in Online Learning Communities: In order to measure students' participation and their online behaviors in learning communities, contents in the posts and comments have been analyzed. Social network analyses (SNAs) were performed on the social networks resulted from the online interactions amongst the participating students. SNA indexes including in-degree centrality, out-degree centrality, closeness, and betweenness [30] were obtained.

V. RESULTS

A. Factor Analyses and Scale Reliability

Quantitative results obtained from the two questionnaires were tested for reliability and validity. For the measurement of SEC, Cronbach's alpha value over the 32 items is .89, which indicates good scale reliability. Exploratory factor analysis (EFA) of the 32 questionnaire items indicated five factors accounting for 52.18% of the variances. For the measurement of CKB, Cronbach's alpha of collaborative knowledge building for the 12 items is .79; which indicates good scale reliability. EFA of the 12 questionnaire items indicated one factor accounting for 32.22% of the variances. This aligns to Scardamalia's one-factor model that reflects the cohesiveness amongst the twelve knowledge building principles [25].

B. Descriptive Statistics and Correlation Analyses

Table III provides descriptive statistics for the measurements of SEC and CKB respectively. The means were obtained from averaging the scores over the items within a scale. Standard deviation (SD) values are also reported.

TABLE III. DESCRIPTIVE STATISTICS OF SEC AND CKB SCALES

Scale	**Mean (SD)**
Social epistemic aims (6 items)	4.14 (0.52)
Structure of social knowledge (6 items)	4.24 (0.47)
Source and justification of social knowledge (7 items)	3.94 (0.54)
Social epistemic virtues (7 items)	4.08 (0.50)
Processes of achieving social epistemic aims (6 items)	3.98 (0.60)
Collaborative knowledge building (12 items)	4.20 (0.42)

The relationship between SEC and CKB was examined. Correlation analyses were performed to study the relationship amongst the five SEC components and CKB (table IV on next page). The results indicate that all of the SEC components are correlated with CKB significantly.

TABLE IV. CORRELATION ANALYSES BETWEEN SEC AND CKB

	Structure of social knowledge	Source and justification of social knoweldge	Social epistemic virtues	Processes of achieving social epistemic aims	Collaborative knoweldge building
Social epistemic aims	.47***	.51***	.55***	.46***	.47***
Structure of social knowledge		.63***	.54***	.48***	.54***
Source and justification of social knoweldge			.53***	.68***	.47***
Social epistemic virtues				.53***	.70***
Processes of achieving social epistemic aims					.58***

Note: ***significant at the .001 level (2-tailed).

C. Online Learning Community Participation and Academic Performance

Students participated in the bloggers' communities through blog posting and commenting. As a result, online learning communities were formed amongst students from same cohort. For example, figure 3 below shows the online social network resulted from social interactions (commenting) over the online learning community established by students from the 2012-13 cohort (N = 54). A node corresponds to an engineering student; a tie between two nodes indicates the occurrence of online interactions between two students through commenting.

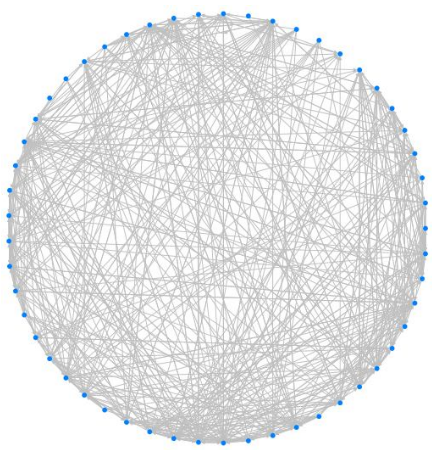

Fig. 3. Sociograph of the social network resulted from the students' interactions within the online learning community.

Since SEC is mediated by online interactions [5], the author examined any relationship between students' online social networking behavior in the learning community and their academic performance. Four SNA indexes, namely in-degree centrality, out-degree centrality, closeness, and betweenness were obtained; which respectively measures the participants' prestige, activity, distances to other members, and potential to control the flow of information. In general, high SNA index values indicate the level of influence of the corresponding node (i.e. participant) [30].

Regression analyses were performed to examine whether students' academic performance can be predicted by their online social networking behavior. The samples of this analysis were taken from 56 students in the 2015-16 cohort who had agreed to participate in the research study. Since one of the four assessment items, blog commenting, was dependent on students' online participation, the author has excluded this item when computing the academic performance scores. Results indicate that academic performance is predicted by closeness (β=.40, F(1, 54)=10.43, p < .01, R^2 = .16), in-degree (β=.30, F(1, 54)=5.33, p < .05, R^2 = .09), and out-degree (β=.28, F(1, 54)=4.59, p < .05, R^2 = .08). In particular, the effect size of closeness on the prediction of academic performance is small to medium. However, betweenness does not predict academic performance (p > .05).

D. Students' Views and Experiences in Online Collaborative Learning

In order to find out students' views on online collaborative learning and the socio-dynamic processes that they have experienced, the author conducted qualitative interviews with students to learn about their thoughts and experiences in online learning community participation. A student described the process and dynamics that he had experienced:

> *Firstly I wrote my own blog and posted it on my own site. Secondly I viewed the blog posts written by my own classmates, and I sometimes wrote comments on their blogs according to my own understanding or experience, and they also commented on mine, too. Thirdly I noticed the history of commenting and clicked into an individual's blog site that I've never been to. I read carefully about his or her blog posts and left the first comment under their blogs. (ZQ-m-12-16)*

Some students expressed that they have gone through the epistemic processes when posting and commenting. For example:

> *I thought about whether I have enough knowledge and information to post my blog posts and comments, as well as whether it is reasonable or logical to ask or comment on my classmate's posts. (JS-f-12-16)*
>
> *…Furthermore, when my visitors wrote comments, I can think deeper about what I have written. (SX-m-12-16)*

One of the students mentioned that the online learning community encouraged her to share more with the classmates. She wrote:

> *I seldom communicate with students in the class. However, in the online learning environment, I can communicate with them across online social networks. I can reach different groups through blog posts with topics that I am interested in. I feel that there is almost no barrier between me and other students. There are no experts or novices as we are all students from the same class. (CW-f-12-16)*

Some students also reported how they have reflected about the contents covered in the lecture through writing blog posts, and that they wrote them carefully because they know other classmates could assess to and comment on the posts.

VI. Discussion

A. Engineering Students' Views on Social Epistemic Cognition and Collaborative Knowledge Building

This study confirms the statistically significant relationship between engineering students' SEC and CKB. Quantitative results obtained from the questionnaires show strong and significant correlations ($p < .001$) between the five SEC components (social epistemic aims, structure of social knowledge, source and justification of social knowledge, social epistemic virtues, and processes of achieving social epistemic aims) and CKB. The current results prove that engineering students' SEC is related to CKB. Such finding connects the emerging SEC framework to the well established body of literatures in knowledge building in an engineering education context, and offers practical insights (to be discussed next) on the enhancement of engineering students' SEC.

B. Socio-Dynamic Processes in Engineering Students' Collaborative Learning

Through active commenting and replying, online social networks were formed amongst the participating students. The author performed SNA on one of the resulted social networks to obtain the centralities indexes, which reflect the positional importance and activity of an actor with the social network. It is proven in the current study that a number of these SNA indexes namely closeness, in-degree, and out-degree are predictors of students' academic performance. This finding is practically important because it confirms the relationship between social networking behavior (i.e. online learning community participation in the course context) and students' actual academic performance.

In addition, students have experienced the socio-dynamics and engaged in social epistemic cognitive processes within the online learning community. It is also noted that a few students spontaneously applied their knowledge on SNA (which they newly learned from the course) and wrote Python programs to performed SNA on their own community. This offers them the experiential learning [31] experience which reinforces their learning and cognitive mastering of the subject knowledge, especially in an emerging and fast growing area such as online social networks and social media.

C. Implications for Practice in Engineering Education

This study obtained a number of scientific results in SEC that can offer practical insights to engineering education. In particular, its research evidences help connecting engineering teaching and learning to the solid theoretical of SEC (namely social epistemology, epistemic cognition and social cognition). In addition, it had been proven in the current work that SEC is strongly related to collaborative knowledge building, and social network participation through online interactions (which is the mediator of SEC) predicts engineering students' academic performance.

However, the current study was performed in a course for social networking where students' participation in the online learning community might have contributed to the result (such that students' academic performance in the course can be predicted by their participation in the social network). More future studies in students' learning in other engineering areas are necessary to confirm the relationship between SEC and engineering students' academic performance in general.

Nevertheless, based on the relationship founded in the current study, one can leverage on the extensive body of literature in CKB (e.g., [2], [23]-[25]) for effective pedagogy and practices that can promote engineering students' SEC including the following aspects.

1. (Epistemic agency). SEC is driven by epistemic aims and social epistemic aims, which is a self-motivated cognitive activity. In a collaborative learning community, students propose their ideas related to the course contents and discussed actively with each others. These social interactions can be supported by an online learning environment. In particular, students can relate their ideas to one another through interacting over the online discourses contributed by other students. In addition, the current work proves that this practice can be successfully implemented by incorporating community participation into the assessment scheme.

2. (Collective responsibility of community knowledge). In a healthy knowledge building community, members contribute ideas which can benefit the others and collectively share the responsibility for the knowledge advancement in the community. This is particularly important to contemporary engineering education because technology and society are both fast changing. Engineering professors are no longer the sole source of knowledge, nor can they learn quick enough to master all novel technologies. Since an online learning community can serve as a collaborative workspace openly accessible by all members, it also hosts the conceptual artifacts [25] that can be disseminated and acquired by all members. In this way, students can have access to a collection of knowledge objects (e.g., in form of blog posts) carefully selected by the participating members within the community.

3. (Symmetric knowledge advancement). As illustrated in figure 2 in the current work, expertise is distributed inside and also across different online learning communities. Through interactions and knowledge exchange amongst the members, knowledge of members who provide and receive online comments can both be advanced upon the exercising of SEC. In addition, community members can bring in external information (e.g., YouTube videos and technology news) that are originally outside the community. In practice, engineering teachers can impose a bonus system to encourage the sharing of useful and relevant online resources. It is also remarked that the ability to select appropriate

resources to tackle complex engineering problem is one of the engineering graduate attributes specified in the Washington Accord [32].

4. (Rise Above). Similar to epistemic cognition, which is the highest amongst the three cognition levels in human individuals, SEC is also a high order cognitive functioning which is driven by epistemic or social epistemic aims; and can result into new knowledge. Pedagogical-wide, engineering teachers can participate in the online learning community and act as a facilitator amongst the student members, so as to support the rise above of new knowledge upon online argumentation and resources exchange.

VII. CONCLUSION

SEC is a framework recently established in the HCI research community. It concerns human individuals' socio-cognitive processes driven by knowledge-related aims. The current work illustrates how the SEC framework and construct can be operationalized within an engineering education context. In particular, the author has presented the course design, implementation, and a number of direct evidences collected from her course. Research results presented in this paper (1) confirms the relationship between SEC and collaborative knowledge building, (2) manifests the socio-dynamic processes supporting SEC and proved the predicting role of online interactions (the mediator of SEC) and engineering students' academic performance, and (3) help offering practical suggestions to engineering education practitioner in the design of effective pedagogies and learning environments to promote engineering students' learning through the promotion of their SEC.

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