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DEVELOPING A NEW INSTRUMENT TO ASSESS ONLINE LEARNERS' SENSE OF COMMUNITY IN COMPUTER-SUPPORTED COLLABORATIVE LEARNING ENVIRONMENTS

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LIHUI LIAO
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DEVELOPING A NEW INSTRUMENT TO ASSESS ONLINE LEARNERS' SENSE OF COMMUNITY IN COMPUTER-SUPPORTED COLLABORATIVE LEARNING ENVIRONMENTS

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

BY

_____
Dr. Maeghan N. Hennessey, Chair

_____
Dr. Barbara Greene

_____
Dr. Mike Crowson

_____
Dr. Ji Hong

_____
Dr. Robert Terry

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DEDICATION

to

My grandfather, Luogang

My parents, Long and Yuqiong

My husband, Wei

My sons, Elliott and Alexander

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Abstract

The purpose of this study is to provide validity evidence for the measurement model underlying a new assessment designed to assess online learners' sense of community in computer-supported collaborative learning communities (SoC in CSCL). A two-level measurement model was proposed based on a comprehensive literature review. The first level included four perceptual constructs and the other level contains eleven instruction-related factors.

In the pilot study, 206 students taking online courses at one university participated. Combination of Exploratory Factor Analysis (*EFA*) and Confirmatory Factor Analysis (*CFA*) was used to refine the measurement model and the instrument. Two perceptual constructs, seven instruction-related factors, and 24 items were left. Results showed acceptable model fit (χ^2 = 409.386, *df* = 209; *RMSEA* = .068, *CFI* = .945, *TLI* = .927) and adequate reliability (α = .944 and ω = .957) for the refined measurement model. In the replication study, 192 online students participated. Results showed acceptable model fit (χ^2 = 436.861, *df* = 207; *RMSEA* = .076, *CFI* = .942, *TLI* = .922) and adequate reliability (α = .961, ω = 967) again in a new sample.

Overall, results indicate that online learners' sense of community is concerned with their feeling of membership and fulfillment of need in that community. Seven instruction-related factors can also account for online leaners' sense of community in CSCL environments. The measurement model functions as a reference for online educators to understand online learners' perceptions and needs in CSCL communities and design specific instructional interventions to facilitate learners' interaction, collaboration, and productivity in online learning environments.

Chapter 1: Introduction of Research Background

Introduction of Distance Education

Schlosser and Simonson (2009) defined distance learning as, "institution-based, formal education where the learning group is separated, and where interactive telecommunication systems are used to connect learners, resources, and instructions" (p.1). This definition is widely accepted in the research field of distance education (Simonson, Schlosser, & Orellana, 2011). *Encyclopedia Britannia 2009 Book of the Year* describes characteristics for current distance education/learning: 1) being carried out by academic institutions, 2) bridging learners in different locations, time zones, culture, and societies, 3) connecting learners and teachers via interactive telecommunication tools, and 4) establishing a virtual learning community where learners and teachers have access to all learning materials, such as books, sound, videos, graphs, and so on. Both the definition and the characteristics emphasize the potential of connecting learners and teachers within geographically separated learning environment.

The learner-to-learner and learner-to-teacher connections have varied in distance education. One of the earliest distance education cases was conducted by Isaac Pitman in the 1840s when postal mail was the most common communication tool for geographically separated people. Isaac Pitman developed the English teaching system of shorthand, known as Pitman shorthand, by mailing texts that were transcribed into shorthand on postcard to students and receiving transcriptions from his students in return for correction (Tait, 2003). With the advancement of communication technology, other platforms of communication among people become available. The spread of film in the 1920s and radio in the 1930s facilitated the employment of television and radio in

distance education (Cuban, 1988). One typical example is the *College-By-Radio* project led by the President of the University of Louisville, John Wilkinson Taylor, who collaborated with the National Broadcasting Company (NBC) to use radio to connect students and teachers in the educational project. The educational purpose was to lower tuition and thus extend higher education to more residents (Cox & Morison, 1999). Students who were not present at the classroom listened to the live classroom discussion by radio as well as received learning materials by mail. Current technological advances and extensive use of computer, World Wide Web, and other network technology render virtual schools and open universities that offer online courses feasible. For instance, the Pennsylvania State University launched *Penn State World Campus* in 1998, which is to provide undergraduate and graduate degree and certificate programs online for the students who cannot attend a Penn State campus ("Penn State World Campus," 2017). Even increasing widely-respected universities like Stanford University and Harvard University participated in this educational trend ("Distance education," 2017). In short, the advancement of communication technology makes distance education easier and faster so that extends the education opportunities to larger population.

Introduction of Current Distance Education

In addition to the advancement of communication technology, in recent years, rising costs, shrinking budgets, and the need to diversify enrollments in education further promote the wide use of online courses. According to *Enrollment in Distance Education Courses, by State: Fall 2012,* reported by National Center for Education Statistics, around 5.5 million undergraduate and graduate students in higher education enrolled in at least one online education course during Fall semester of 2012,

accounting for around one quarter of the total course enrollment of that year (Ginder, 2014). The courses included the completely online courses and hybrid courses that blend face-to-face and online learning. The enrollment in online courses has remarkably increased from 2002 to 2012, and this trend is expected to continue (Ginder, 2014).

Along with the wide spread of online enrollment, learning theories have evolved from behaviorism to constructivism. The evolution optimizes the online instructional design. Behaviorist theories held that learning is observably behavioral change through stimulus. Based on this perspective, online educators fragmented knowledge in a logical sequence and used computerized drill and practice to reinforce learners' memorization of the fragmented knowledge (Stahl, Koschmann, & Suthers, 2006). Influenced by later cognitive theories, which stressed on analyzing leaners' mental models and representation of learning process, educators advocated learners' understanding process and teachers' immediate response to learners' actions, especially on occurrence of cognitive errors (Stahl et al., 2006). Piagetian constructivism held that learners generated their own understanding of knowledge within context. Influenced by this learning theory, educators believed one could autonomously initiate and regulate his or her own knowledge acquisition under the impact of environment rather than exclusively depending on teachers' instruction and behavioral reinforcement (Bandura, 1986; Zimmerman, 1989). Accordingly, instructional designers provided stimulating online environments for learners to explore and reason knowledge by themselves (Stahl et al., 2006). From behaviorism to Piagetian constructivism, the design of online learning environments paid more attention to individual cognitive processes and learning outcomes than interpersonal connections. Despite incorporating online discussion,

learning in online formats consisted of task-related interaction did not completely meet learners' basic needs of connecting to others and being taken care of by others (Deci & Ryan, 2000). Therefore, distance learning was often seen as isolated, inhuman, and anti-social (Stahl et al., 2006).

In recent decades, constructivists have advocated for social constructivism, which addresses people's understanding and constructing meaning via ongoing conversation or collaboration with one another (McKinley, 2015). Under this theoretical framework, the educators' focus is transferred from internalized individual knowledge acquisition to shared knowledge construction (Hadwin, Järvelä, & Miller, 2011). Due to the new educational focus, Computer-Supported Collaborative Learning (CSCL) arose in the 1990s to solve the problem of isolated distance learning (Stahl et al., 2006).

CSCL is characterized by using computers and the Internet to synchronously or asynchronously share and construct knowledge (Weinberger, Ertl, Fischer, & Mandl, 2005; Weinberger & Fischer, 2006), which involves reflective communication, respectful interdependence among distant learners, and mutual understanding in a collaborative learning community (Garrison, 1997; Henri & Rigault, 1996). CSCL has been shown to have positive effects on promoting motivation, critical thinking, shared understanding, retention of acquired knowledge, and students' engagement in the construction of new ideas and concepts (Benbunan-Fich, 1997; Garrison, Anderson, & Archer, 2001; Johnson & Johnson, 1999; Slavin, 1990). Given the positive effects of CSCL, many educators and researchers are interested in exploring the following areas of CSCL:

- How to facilitate students' performance in CSCL environments (Dewiyanti, Brand-Gruwel, Jochems, & Broers, 2007; Jones & Issroff, 2005; Kreijns, Kirschner, Jochems, & van Buuren, 2007; Rienties, Tempelaar, Van den Bossche, Gijselaers, & Segers, 2009);
- How to measure or assess learners' CSCL procedures (Gress, Fior, Hadwin, & Winne, 2010; A. Weinberger & Fischer, 2006);
- How learners perform in CSCL environments (de Laat, Lally, Lipponen, & Simons, 2007; Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003; Pozzi, Manca, Persico, & Sarti, 2007); and
- How to scaffold students to achieve their collaborative learning goals (Dillenbourg & Tchounikine, 2007; Frank Fischer, Kollar, Stegmann, & Wecker, 2013; Janssen, Erkens, Kanselaar, & Jaspers, 2007; A. Weinberger et al., 2005; Zurita & Nussbaum, 2004).

However, recent research has shown negative consequences of CSCL (Azevedo, 2007; de Jong, Kollöffel, van der Meijden, Staarman, & Janssen, 2005; Salovaara, 2005). For instance, Kwon, Liu, and Johnson (2014) identified that learning groups in CSCL environment fell into patterns of poor group regulation on collaborative learning tasks and dormant socio-emotional interaction patterns because of increased cognitive load and the complexity of ill-structured problem solving. In addition, Janssen and his colleagues (2012) found discussion and task-related regulation in CSCL did not exert significant influence on group performance, and even social interactions during group learning did not positively affect learning outcomes. CSCL conditions were deemed to impede students to collaboratively solve complex problems that do not have fixed

solutions (Azevedo, 2007; de Jong et al., 2005; Salovaara, 2005). To be specific, the extended time spent on problem solving in CSCL (Baltes, Dickson, Sherman, Bauer, & LaGanke, 2002) and the inevitable absence of immediate guidance from instructors (Azevedo, Cromley, Winters, & Moos, 2004; de Jong et al., 2005) caused lower satisfaction in learning. Moreover, learners usually stood on unequal academic and social status in their learning communities (Cohen, 1994) so they were not likely to generate a feeling of connectedness with each other (Kreijns, Kirschner, & Jochems, 2003; Wendt & Rockinson-Szapkiw, 2015). In addition, online instructors assumed that social interactions in CSCL environment happened automatically as in a face-to-face learning environment, and thus they restricted interaction to task-related cognitive processes, neglecting scaffolding on social interaction or (Kreijns et al., 2003). In short, the causes for the negative consequences in CSCL environment can be summarized as the limitations of CSCL itself; namely learners' emotional alienation and instructors' pedagogical stereotyping of instructional design.

Among these causes, emotional alienation is more likely to happen in online learning communities. Emotional alienation is a feeling of loneliness due to the lack of intimate relationship with others in a community, sense of the inability to influence others in a community, and rejection of dominant social and cultural norms (Rovai & Wighting, 2005). In an online learning community, physical separation among online learners is inevitable; learning time is often asynchronous (Morgan & Tam, 1999). Moreover, distance educators and instructional designers often neglect instructional interventions for online learners' emotional connection (Kreijns, Kirschner, & Jochems,

2003). Hence, emotional alienation can happen much more easily in online learning environments than face-to-face learning environments.

Research Needs

In order to address online learners' emotional alienation, Increasing their sense of community in CSCL environments could be one of the mechanisms to solve the problem (Palloff & Pratt, 1999). Sense of community has been shown to be a stimuli of strong motivation, high-quality interactions, increased critical thinking, and positive learning outcomes (Abfalter, Zaglia, & Mueller, 2012; Haythornthwaite & Wellman, 1998; Rovai, 2002b; Townley et al., 2013; Tu & Corry, 2002). In this case, the perceptual constructs leading to sense of community in CSCL environments need to be identified. To investigate the appropriateness of the constructs identified as encompassing sense of community in CSCL environments, an instrument should be developed and tested, for which the measurement model underlying the instrument should be defined based on a comprehensive literature review.

Need for a Theoretical Framework of Sense of Community in CSCL

Seymour Sarason is considered to be the first psychologist studying sense of community (Fremlin, 2015). He defined sense of community as "the sense that one was part of a readily available, mutually supportive network of relationships upon which one could depend and as a result of which one did not experience sustained feelings of loneliness" (Sarason, 1974, p. 1). Bachrach and Zautra (1985); Doolittle and MacDonald (1978); Riger and Lavrakas (1981); and Riger, LeBailly, and Gordon (1981) identified people's different levels of sense of community via measuring people's behaviors(e.g., interaction and familiarity with neighbors, residency status, use

of local facilities, privacy and anonymity provided by communities, etc.) and attitude (e.g., preference for neighbor interaction, desire to participate in neighbors' affairs, feeling of part of neighbor, feeling at home in communities, agreement with the values and beliefs of communities, interest in what goes on in communities, etc.). McMillan and Chavis (1986) critiqued these identifications or conceptualizations as they did not contribute to an elaborated theoretical understanding of sense of community. Further, McMillan and Chavis (1986) articulated the nature of this concept in terms of a four-perception framework: membership, influence, integration and fulfillment of needs, and shared emotional connection. They also framed how the four perceptions dynamically work together to generate and maintain sense of community. Ten years later, McMillan (1996) reformulated the theoretical framework, which consisted of spirit, trust, trade, and art, but still kept the essentials of the four perceptions proposed before (Nistor, Daxecker, Stanciu, & Diekamp, 2015). These conceptual models for sense of community are now broadly accepted and applied in the field of psychology ("Sense of community," 2016).

Nevertheless, sense of community is setting specific (Hill, 1996; Rovai, 2002b), which means sense of community is the psychological consequence of living or acting in a community. Hence, individual attitudes or emotions associated with the sense of community may vary due to different community goals, norms, and values (Blanchard & Markus, 2004; Brook & Oliver, 2002). Likewise, sense of community in CSCL should emerge from the primary event in CSCL environments, such as introductions, collaborative group work, sharing personal experiences, online synchronous discussion, exchanging resources, and so on (Shackelford & Maxwell, 2012). Hence, exploration of

the specific definition and theoretical framework of sense of community in CSCL environments is necessary for us to comprehensively understand the new concept.

Need for a New Instrument Assessing Sense of Community in CSCL (SoC in CSCL)

To investigate the appropriateness of the explored construct structure, developing an instrument in terms of the theoretical framework is needed to reach the goal. A few researchers borrowed existing instruments assessing interpersonal connection in communities to assess learners' sense of community in online learning communities, but they did not pay adequate attention to characteristics of CSCL. Bollen and Hoyle (1990) created *Perceived Cohesion Scale (PCS)*, a six-item instrument assessing learners' sense of belonging and morale in a face-to-face learning community. Salisbury, Carte, and Chidambaram (2006) studied the specific characteristics of small online learning groups and considered it necessary to examine whether the factorial structure and psychometric properties underlying the *PCS* instrument can be extended to the virtual learning setting. Their findings showed the factorial stability of *PCS* in virtual learning teams; so, they kept the six items and tailored the statements of the six items to fit the virtual learning setting. Later, Rovai (2002a) conducted a literature review about sense of community regardless of learning environments and proposed five factors for the concept of sense of community: feelings of connectedness, cohesion, spirit, trust, and interdependence among members. Based on the factor structure, Rovai (2002a) designed the 40-item *Classroom Community Scale* to represent the proposed five factors for either traditional or virtual learning communities, and validated the new scale. Finally, Rovai (2002a) shrank the scale into a 20 items and found two interpretable factors underlying the scale, feelings of connectedness and learning.

Abedin, Daneshgar, and D'Ambra (2010) conducted a literature review about what factors might effectively influence online learners' sense of community and accordingly sought out previous instruments assessing the factors. Hereafter, the researchers put the previous instruments together to examine the underlying dimensions of sense of community in CSCL. Finally, two constructs stood out based on results of an exploratory factor analysis: sense of cohesion and awareness of others. However, the instruments mentioned above all rooted from the studies on face-to-face learning communities and thus might overshadow the characteristics of CSCL communities. An instrument designed to represent the setting-specific characteristics of CSCL may be necessary.

Need for Validity Evidence to Develop the New SoC in CSCL Instrument

In order to ascertain the extent to which the new instrument is designed to measure sense of community in CSCL, validity evidence on its structure is necessary. According to the Standards for Education and Psychological Testing published by American Educational Research Association (AERA), American Psychological Association (APA), and National Council on Measurement in Education (NCME) (2014), validity evidence is the most important consideration in measurement development and evaluation. In addition, given the validity evidence, instructors may make use of the new instrument to assess their online students' sense of community in CSCL and accordingly conduct the instructional interventions to promote a productive CSCL.

What construct validity evidence should be provided for the instrument development of *SoC in CSCL*? Messick (1989) claimed that construct validity plays an

overarching role in test validation and entails six categories of evidence that are provided for different purposes in validation:

- Content evidence: The extent to which the content of a test is aligned with individual behaviors and performance domain that the test intends to measure,
- Structure evidence: The extent to which test scores represent the internal structure of the test that is supported by theoretical or empirical evidence,
- External evidence: The relationship between the interested test and criterion tests. This evidence consists of convergent evidence and discriminate evidence. The former refers to whether the interested test shows correspondence with related criterion tests. The latter means how the interested test discriminates the criterion tests, which measure the constructs dissimilar with the ones that the interested test intends to measure,
- Substantive evidence: Individuals' cognitive processes underlying the procedures of responding to items or completing tasks in a test,
- Generalizability evidence: The degree to which the internal structures of a test can be replicated across time, groups, settings, and other sampling conditions, and
- Consequential evidence: The intended and unintended social consequences of using and interpreting test scores.

Methods of construct validation. Messick proposed that construct validation "embraces all of the experimental, statistical, and philosophical means by which hypotheses and scientific theories are evaluated" (1990 p. 14). He believed there are various methods for construct validation, and these methods should be centered on

evaluating whether the inferences from observations to intended interpretation and use of test score are adequately supported by theoretical and empirical evidence. In addition, Messick (1989) pointed out that construct validation does not lead to a summative decision about whether a test is developed well enough to be published, but provides references for modifying the test. However, Cronbach (1989) claimed that if test developers cannot find a well-defined theory or provide adequate empirical evidence supporting the measurement model of a test, construct validation will be an endless process. In this case, Kane (2016) proposed the argument-based approach, which is a systematic and simpler approach for construct validation. This approach involves two arguments: the interpretation/use argument and the validity argument.

Interpretation/use argument. The interpretation/use argument requires test development to establish the logic-argument-driven inferences from observed data to intended interpretation and use of test scores. According to Kane (2016)'s theory, test developers may conduct the following inferences:

- Scoring inference: Making assumption about the accuracy of scoring system, criterion, and models,
- Generalization inference: Generalizing the observed performance to a universe of expected performance,
- Extrapolation inference: Using the observed performance to predict different kinds of performance in different context, and
- Decision inference: Evaluating whether test interpretation leads to negative social consequences.

To establish the above inferences, test developers should identify the test takers, context, and purposes. For example, the *Common Core State Standards* indicate a series of knowledge and skills in English language arts and mathematics that K-12 students should acquire by the end of each grade. The *Common Core State Standards* are advocated and employed in forty-two states and the District of Columbia, and guide the curriculum design and test development of these areas in the United States ("Common Core State Standards Initiative," 2016). Academic experts and educators developed the *Common Core*, going through logic arguments including claims, reasoning, and relevant evidence. In addition, politicians, analysts, and commentators also participated in the development through providing support and criticism. In the process of developing the logic argument, inferences regarding the appropriateness of the interpretation and use of the *Common Core* were established ("Common Core State Standards Initiative," 2016).

Validity argument. Kane (2016) stated that the validity argument attempts to evaluate the inferences established by test developers. Kane (2016) discussed the specific validation methods for the inferences as below.

For the scoring inference, test developers evaluate whether a test's scoring system is appropriate. Usually, a panel of experts who develop the scoring criteria review its appropriateness. In addition, test raters can also provide evidence of rating consistence.

For the generalization inference, test developers evaluate whether the observed performance can be generalized to the expected performances that a test aims at measuring. Usually, reliability scores (e. g., Cronbach's alpha) are statistical evidence of the degree to which observed data are representative of the expected performances. If

test scores are stable or consistent across different observational conditions (including items, time, context, samples, etc.), we can claim that the measured performance in the test is representative and thus, they can be generalized to the expected performances (Brennan, 2001). In addition, Cronbach's alpha values of the overall scale and each subscale are calculated to indicate the generalizability over items. Most psychological scientists and educators suggest that the acceptable level of reliability for ability or aptitude tests is .80 and for personality tests is .70 (DeVellis, 2016). If reliability is over .90, it means the items of a test are consistent with one another. When reliability is below .60, the items cannot be generalized to the expected performances; they must be modified or replaced by new items. Furthermore, test-retest reliability is another way to assess the stability of a test. Usually, the first and second administrations of a test should be given some time apart, and then correlation of scores in the two administrations should be calculated. The value of correlation suggests that the extent to which the test scores are stable across different sampling time and contexts. Given adequate correlation, we can make the claim that measured performance is not affected considerably by errors, and individuals' scores of the test can represent expected performance.

For the extrapolation inference, test developers use empirical and analytic evidence to evaluate whether performances assessed in tests can be extended to expected performances in target domain of the test. It is impossible for a test to involve all expected performances in target domain of the test; in reality the tested performances are subset of the target domain (AERA, APA, NCME, 2016). Empirical evidence is necessary in addition to the degree of item representativeness, which can be generated

from correlation or regression analyses between the test scores and criterion scores. In addition, analytic evidence can also evaluate the extrapolation inference. If test developers can make a reasonable claim that the performance or abilities assessed in a test cover most of the domain target, the extension from the limited observations in a test to the full range of performances in target domain can be seen plausible.

For the theory-based inference, statistical evidence is necessary to evaluate the model fit of performance or abilities observed in a test to the measurement model of the test. For example, Confirmatory Factor Analysis (*CFA*) can be used to examine whether behavioral and emotional indicators observed in a test match with the measurement model underlying the test. In *CFA*, fit indices are examined, such as *RMSEA*, *CFI*, *TLI*, etc. If the fit indices reach the standards that were widely accepted by researchers, test developers can claim that measurement model reproduce observed data. If not, there can be two causes: construct underrepresentation or irrelevant variance involvement (Messick, 1989). Construct underrepresentation pertains to theory-driven constructs that are too narrow, or the relationship among the constructs is modeled too simply so fit indices show misfit between construct models and observed data. Test developers could modify construct models, synthesizing literature review and statistical recommendation from CFA output. The second cause is overrepresentation, which refers to theory-driven construct models that involve some irrelevant behavioral, and/or perceptional factors or other variance outside the intended models. Test developers can detect the irrelevant factors via statistical analyses and reviewing testing design and administration. After correcting these issues, researchers can collect new data and statistically investigate again the fitness between the modified construct models and the new empirical data.

For the decision inference, test developers can statistically evaluate whether designed tests reach the intended measurement goals and whether or not the interpretation and use of test scores lead to negative social consequences. For example, specific instruments assessing readability of test items can be administrated to investigate whether a test is used as intended. In addition to the statistical evidence, test developers can discuss whether there are biases in score interpretation, such as whether or not test scores have different meaning to different groups of test takers; whether or not examinees are treated equally in a test administration; whether or not test takers are provided equal opportunities to learn test materials, and whether or not a test systematically under-represent the performance of some groups of test takers, and so on (AERA, APA, & NCME, 1999). Some strategies are identified to avoid the biases, such as consulting administrators and scorers to review test materials, conducting representative sampling method, screening for and deleting the items that could produce cultural and racial conflicts, providing translated versions of a test if needed, using multiple measures to assess the intended performances or aptitudes, and so on ("Test Bias Definition" 2013).

Construct validation in the present study. Messick (1989) proposed that construct validity plays an overarching role in test validation and entails six categories of evidence for different purposes in validation. In the present study, I will use the literature-review supported construct structure as a measurement model to develop the new *SoC in CSCL* instrument. Validity evidence is necessary to evaluate whether or not the observed data can represent the measurement model (Kane, 2016). Therefore, the present study will pay more attention to structural evidence (i.e., the extent to which

instrument scores represent the measurement model underlying the *SoC in CSCL* instrument).

The *SoC in CSCL* instrument is brand new in both fields of online education and sense of community. Therefore, external evidence is indispensable to support the extrapolation inference about whether online learners' perceptions assessed in the instrument can be extended to the expected perceptions in target domain of the instrument (Messick, 1989; Kane, 2016). Sense of community in CSCL is closely related to learners' self-efficacy and perceptions of the intrinsic value on CSCL (Wang & Newlin, 2002; Wang & Hwang, 2012; Wang & Lin, 2007). Hence, the correlation between these two external variables and sense of community in CSCL needs to be investigated.

It is important to remember that validation is an ongoing process, which means the *SoC in CSCL* instrument should be continuously revised with the update of validity evidence (Messick, 1995). Validation is not an activity that ends once the quality of a test is announced good enough to be published. Moreover, sampling conditions may influence the result of construct validation. The measurement model of an well-developed instrument should be replicated across different samples and times to maintain scientific integrity, so that the observed performance in a test can be generalized to a universe of expected performance which the test aims at measuring (Burman, Reed, & Alm, 2010; Kane, 2016). Hence, the generalizability evidence is also needed for developing the new *SoC in CSCL* instrument.

Research Purposes

Based on the research needs, the dual purposes of this study are as follows:

1) Identify the theoretical framework of the concept of sense of community in CSCL.
2) Develop the *SoC in CSCL* instrument using the theoretical framework.

In order to reach the research purposes, I will explore the theoretical framework of the concept of sense of community in CSCL via conducing a comprehensive literature review. I will use the theoretical framework as a measurement model to design the new *SoC in CSCL* instrument, and then will collect data and analyze how the measurement model can be explained by the observed data. Based on the results, I will refine the measurement model and will accordingly modified the new instrument.

Research Questions

Based on the research purposes and the general procedure to reach them, this study aims at answering the following research questions:

1. What is the measurement model of the new *SoC in CSCL* instrument?
2. How is the literature-review-supported measurement model supported by statistical evidence?
    1) How is the literature-review-supported the measurement model underlying the new *SoC in CSCL* instrument explained by observed data?
    2) Are scores obtained from the *SoC in CSCL* instrument reliable?
3. Can the refined measurement model be replicated in a new sample?
    1) How is the refined measurement model underlying the modified *SoC in CSCL* instrument explained by observed data?
    2) Are scores obtained from the modified *SoC in CSCL* instrument reliable?

4. Are online learners' scores on the two criterion instruments, *Self-Efficacy Instrument* (*SEI*) and *Intrinsic Value Instrument* (*IVI*), highly correlated with their scores on the modified *SoC in CSCL* instrument?

Chapter 2: Literature Review

The purpose of Chapter 2 is to explore the theoretical framework of the concept of sense of community in CSCL environments. I will use the theoretical framework as a measurement model to develop the *SoC in CSCL* instrument. A comprehensive literature review will be conducted to explore the theoretical framework. Specifically, McMillan and Chavis (1986) and McMillan (1996) proposed four correlated perceptual constructs for the concept of sense of community, which scaffold my literature review. Given the perceptual constructs, I will additionally explore eleven instruction-related factors that can influence the four perceptual constructs via reviewing empirical research in the field of CSCL. The four perceptual constructs and eleven instruction-related factors will jointly profile the concept of sense of community in CSCL environments.

Identification of Empirical Research

Three resources were employed to identify empirical research that discussed instruction-related factors that could influence online learners' sense of community in CSCL environments. First, *EBSCOhost*, *WEB OF SCIENCE*, and *Google Scholar* served as the primary resource pools to identify relevant empirical research. Second, the reference list at the end of the initially identified publications were other important empirical research pool. Third, the tables of contents of relevant educational journals, such as *Computer and Education*, *Instructional Science*, *International Journal of Computer-Supported Collaborative Learning*, etc., were also reviewed to search the studies that were not included in the last two empirical research pools.

The identification of empirical research used to explore the theoretical framework followed three criteria. First, the selected empirical research involved online synchronous or asynchronous peer interaction but were not limited to this interaction. Second, although online class interactions were the focus of this review, research where online and face-to-face meetings were mixed were still included, but only when the online meetings were the primary learning form used in the classes. This requirement is because important individual perceptions of CSCL are prone to overgeneralization and incorrect conclusions (Schreiber & Engelmann, 2010), and group members usually lack correct impression formation and bonding among members at the beginning of CSCL (Kreijns et al., 2003; Wendt & Rockinson-Szapkiw, 2015). Through face-to-face meetings, group members share cognitive, social, and affective information to update their impression entries to bond with each other. Therefore, many current online education classes involve face-to-face meetings regularly or at the beginning of online learning. Third, the selected studies involved intensive collaborative learning, which included but were not limited to online learners' asking and answering questions when misunderstandings occurred, or clarification of meaning was necessary. It is because during the intensive collaborative learning, online leaners have more opportunities of deep interaction and thus are more likely to establish close relationship with the others (Kreijns et al., 2003). The most intensive form of collaborative learning usually occurs upon formation of shared knowledge understanding and collaborative problem solving. In other words, the selected studies involved online learners' sharing individual knowing and ideas, monitoring group work, repairing conflict, justifying alternative

problem solutions, and evaluating group performance (Ge & Land, 2004; Roschelle & Teasley, 1995).

Identification of the Two-Level Theoretical Framework

In this literature review, I identified the theoretical framework of the concept of sense of community in CSCL environments using four steps. First, I explored and understood the four correlated perceptual constructs of sense of community proposed by McMillan and Chavis (1986) and McMillan (1996). Second, I adapted the original four perceptual constructs to CSCL communities, synthetically considering the characteristics of CSCL and McMillan and Chavis (1986) and McMillan (1996)'s rationality in profiling sense of community. Third, scaffold by the adapted four perceptual constructs, I additionally explored eleven instruction-related factors that could influence the four perceptual constructs via reviewing empirical research in the field of CSCL. At last, the four adapted perceptual constructs and eleven instruction-related factors jointly profiled the two-level theoretical framework of the concept of sense of community in CSCL environments (Table 1).

One was perceptual level, which included four perceptual constructs: *Feeling of Membership*, *Influence towards Conformity*, *Strengthened Motivation*, and *Awareness-Driven Emotional Connection*. The perceptual level was derived from McMillan and Chavis (1986) and McMillan (1996)'s four-construct framework for the concept of sense of community, but later tailored to online collaborative learning environments. The other was instruction-related level, which contained eleven instruction-related factors that might influence the four perceptual constructs.

Table 1

Two-level Theoretical Framework of Sense of Community in CSCL Environments

Perceptual Constructs	Instruction-related Factors
Feeling of Membership	• Close Socio-Emotional Relationship • Sense of Ease • Senses of Self- and Collective Efficacy
Perception of Influence	• Adaptation to Group Regulation • Efforts for Group Consensus
Fulfillment of Needs	• Sense of Leadership to Group Learning • Benefitting from Diverse Resources • Benefitting from Homogeneous Value • Achievability from Contribution to Group Success
Emotional Connection	• Cognitive Awareness • Social Awareness

Perceptual Level of the Theoretical Framework

Feeling of Membership

McMillan and Chavis (1986) and McMillan (1996) defined feeling of membership as the consequence of five attributes' circular self-reinforcement, including feeling of belonging, personal investment, boundary, emotional safety, and common symbol system. According to McMillan and Chavis (1986)'s definition, feeling of belonging is a basic need of human beings, which means people always search for a community that shares values or norms with them to experience a sense of belonging. In order to generate the sense of belonging, individuals invest efforts to get accepted by others of a community. Feelings of belonging and acceptance leads to boundary, which determines who belongs to a community and who does not. Once people bond with others in a community, they feel group intimacy and emotional safety, which in reverse maintains sense of belonging and boundary and increases personal investment. In addition, when people bond with one another and feel safe emotionally, a common symbol system develops through dress, language, myth, rituals, rites, ceremonies,

holidays, and so on. The common symbol system reversely enhances people's sense of belonging and boundary.

Based on McMillan and Chavis (1986)'s definition, in CSCL communities, online learners' feeling of membership should have a similar circular self-reinforcement pattern. Likewise, online learners have a need to feel they belong to online learning communities or their online learning groups because they have an inherent drive to satisfy the basic need of being tied with others in learning communities (Ryan & Deci, 2000; Walker & Greene, 2009). In order to keep away from isolation, individuals contribute to collaborative learning tasks and establish close relationship via active interaction with the others (Hagerty, Lynch-Sauer, Patusky, Bouwsema, & Collier, 1992; Hagerty & Patusky, 1995). Especially, via social interaction, online learners establish a sound socio-emotional relationship with the others, trusting one another and conducting more task-related interaction (Kreijns et al., 2003). Once online learners' attempt to participate in any online interaction is recognized and accepted by others in online learning communities, their fear, anxiety, and even apprehension that most online learners experienced especially at the beginning of an online learning (Conrad, 2002) will be relieved considerably. According to social cognitive theory, relief of anxiety or sense of ease provides a cue for learners to positively judge their own and even their learning groups' capabilities of achieving online collaborative learning goals (Bates & Khasawneh, 2007). With the positive judgement of self and group efficacy, online learners tend to interact with the others and contribute more to online collaborative learning (Wang & Hwang, 2012; Wang & Lin, 2007). To sum up, feeling of membership in CSCL is concerned with three self-reinforced factors: close socio-

emotional relationship rooted in active interaction, sense of ease, and senses of self- and collective efficacy.

Perception of Influence

In the four-perception frameworks of McMillan (1996) and McMillian and Chavis (1986), perception of influence is a bidirectional psychological process, in which individuals concurrently perceive the pressure from communities to conform themselves with others and the capability to influence others in communities. That is, a community validates its members via creating behavioral norms to conform members' views or actions. On the other hand, individuals in the community are inherently apt to bring the other members' knowledge and action into line with theirs. Briefly, the bidirectional influence refers to the perceived pressure and the tendency of members towards conformity. In CSCL communities, perception of influence towards conformity also exists for online learners, which could reflect in individual adaptation to group regulation and efforts for group consensus. That is, individual learners would like to accept group regulation on achieving collaborative learning goals because they can obtain a number of social and academic benefits from the group regulation, especially from the more regulated peer (DiDonato, 2013). In addition, individual leaners have to explain and elaborate their knowing and views and comment on others' ideas on group work to reach group consensus on knowledge construction or complex problem solving (Janssen, et al, 2007).

Fulfillment of Needs

McMillan and Chavis (1986) and McMillan (1996) defined fulfillment of needs as a reinforcement to motivate people's behaviors in communities. Community

members can be motivated to increase their personal investment to communities if anyone of the three needs are fulfilled: 1) leading status, 2) benefitting from the other members' competence or capabilities, and 3) contribution to group success. In addition, McMillan and Chavis (1986) asserted that community members might have various priorities of emotional and intellectual needs to meet since different families and sociocultural backgrounds shape them. Hence, the extent to which people in communities share the type and the priority of the needs to meet predicts the strength of sense of community. Based on McMillan and Chavis (1986) and McMillan (1996)'s definition, in CSCL communities, fulfillment of needs should motivate online learners to contribute to online collaborative learning. Considering the characteristics of CSCL, I contextualized the fulfillment of needs proposed by McMillan and Chavis (1986) as following: 1) sense of leadership to group learning, 2) benefitting from group members' diverse resources and homogeneous value, and 3) achievability from contribution to online group learning success. These perceptions respectively fulfill learner's' needs of autonomy, relatedness, and competence, which intrinsically motivate group members to bond more closely with one another to do collaborative learning (Ryan & Deci, 2000).

Emotional Connection

McMillan & Chavis (1986) and McMillan (1996) claimed that community members could be tied with each other emotionally through sharing events that end with positive consequences. The positive consequences could be active interaction, getting tasks resolved, valuing shared events, intimacy, honor, and spiritual bond. There is no necessity for members to synchronously participate in events of the kind, but must be aware of them. According to McMillan & Chavis (1986) and McMillan (1996)'s claim,

in CSCL communities, emotional connection should form when learners engage in online collaborative learning activities and value the positive consequences of the activities. The positive consequences could be any one or mix of the three perceptions (i.e., feeling of membership, influence towards conformity, fulfillment of needs). The emotional connection can be displayed as group awareness, which denotes getting familiar with other learners and caring about what happens in online learning communities (Abedin et al., 2010; Abedin, Daneshgar, & D'Ambra, 2011). The level of group awareness has been demonstrated highly correlated with senses of isolation and acceptance of other learners (Abedin et al., 2010; Abedin, et al, 2011). Group awareness fall into two categories: cognitive awareness and social awareness (Dehler, Bodemer, Buder, & Hesse, 2011; Janssen, Erkens, & Kirschner, 2011). Cognitive awareness pertains to the idea that individuals get aware of other learners' cognitive information in CSCL environments, such as individual knowledge structure and group knowledge distribution (Janssen et al, 2011). Social awareness refers to awareness of group learners' participation rate, contribution quality, and social traits (Janssen et al, 2011; Buder & Bodemer, 2007).

In short, in CSCL environments, each perceptual construct was associated with two to four factors. Feeling of membership was concerned with three self-reinforced factors: close socio-emotional relationship rooted in active interaction, sense of ease, and senses of self- and collective efficacy. Perception of influence was related to two factors: individual learners' adaptation to group regulation and efforts for group consensus. Fulfillment of needs was derived from three factors: sense of leadership to group learning, benefitting from group members' diverse resources and homogeneous

value, and achievability from contribution to group success. Emotional connection could be displayed as two factors: cognitive awareness and social awareness.

However, in the research field of CSCL, there was no direct evidence to demonstrate the relationship among the perceptual constructs, the associated factors, and sense of community in CSCL environments. Instead, some empirical research investigated how instructional interventions on the factors promoted learners' online collaborative performance and emotional coherence, which will be discussed in detail later.

Instruction-Related Level of the Theoretical Framework

Close Socio-Emotional Relationship

CSCL is conducted through synchronous or asynchronous interaction, where the primary events are to share learning information and collaboratively construct knowledge (Weinberger et al., 2005; Weinberger & Fischer, 2006). Therefore, most researchers and educators believed that the interaction ought to be oriented by learning tasks or other educational purposes (Kreijns et al., 2003). Active task-related interaction has long been seen as the key to productive CSCL and thus has captured plenty of focuses of instructional designers and researchers (Baker & Lund, 1997; Dillenbourg, 2002; Jermann & Schneider, 1997; Kreijns et al., 2003). However, task-related interaction does not always occur automatically (Dillenbourg, 2002; Johnson & Johnson, 1989, 1999) especially in text-based online learning communities where communication media is limited (Kreijns et al., 2003). The limited communication probably leads to emotional distance among online learners and thus negatively affects the task-related interaction. Although task-related communication happens frequently in

CSCL environments, it does not necessarily indicate a high-quality interaction, because online learners might spend too much time on low-level web-based discussion. For example, online learners might keep representing their own independent and often unilateral understandings and ideas, instead of effectively coordinating their understanding and ideas with the others' (Järvelä & Häkkinen, 2013).

Promotion of social-emotional interaction was proposed to solve the communication limitation in CSCL environments (Abedin, Daneshgar, & D'Ambra, 2012; Kreijns et al., 2003). Promotion of social-emotional interaction aims at "getting to know each other, committing to social relationships, developing trust and belonging, and building a sense of online community" (Kreijns, Kirschner, & Jochems, 2003, p. 342). This aim suggests that interaction in CSCL environments should not only be task-oriented, but also establishing and maintaining a sound socio-emotional relationship among online learners. In reverse, a sound social-emotional relationship, such as friendship, camaraderie, reciprocity, etc., enhances members' willingness of communication, exploration of new network linkage, individual accountability, and positive interdependence in CSCL (Cho, Gay, Davidson, & Ingraffea, 2007; Flowers, 2015; Wang, 2009).

Sense of Ease

Sense of ease mentioned in the present study denotes that individuals feel comfortable while communicating with others or doing online collaborative learning tasks, and perceive sociability and thus are more willing to engage in online collaborative learning. In CSCL communities, sense of ease is derived from online

learners' smooth use of technology and feeling of interactivity (Kreijns, Kirschner, & Jochems, 2002; Kreijns, Kirschner, Jochems, & van Buuren, 2007).

Sense of ease generating from use of technology is concerned with two perceptions: 1) the degree to which one perceives effortless to use online learning technology and 2) the extent to which one perceives the positive effect of online learning technology on individual learning. The two-factor model roots in the technology acceptance model (TAM) proposed by Davis, Bagozzi, & Warshaw, (1989), which explains the variance in users' intention of using technology. This model was demonstrated valid in the field of distance education to predict students' willingness to use similar online course websites in the future (Chang & Tung, 2008; Park, 2009; Saadé & Bahli, 2005). First, perceived effortlessness on using online learning technology is generated from convenient access to website, satisfactory web browsing speed, user-friendly screen design, easy navigation of interface, and so on. The perceive effortlessness has been demonstrated as a critical factor to promote academic achievement (Selim, 2007; Volery & Lord, 2000) and peer interaction (Liu, Chen, Sun, Wible, & Kuo, 2010). Second, perceived effectiveness on using online learning technology denotes the extent to which the technology are believed to be capable of enhancing online learners' performance (Saadé & Bahli, 2005) and emergence of a sound social space (Kreijns et al., 2002). According to Liaw (2008) and Liu et al. (2010)'s research, the perceived effectiveness significantly predict learners' behavioral intention and perception of online learning. It should be noted that the perceived effectiveness was also influenced by learners' characteristics (e.g. self-efficacy, self-

directedness, previous online learning experience, etc.) and properties of online learning technology (e.g. Internet speed, online learning functions, interaction interface, etc.).

The second resource of sense of ease is individual feeling of interactivity. Interactivity refers to "the form, function, and impact of interactions" in online learning communities (Muirhead & Juwah, 2004). Interactivity does not simply refer to a dialogue, discourse or event, but a message loop starting from and getting back to an online learner's point of view and affective benefits produced in the message loop (Muirhead & Juwah, 2004; Yacci, 2000). Preece (2001) claimed interactivity varies in different types of online learning communities and the variance could be discussed in terms of the depth and breadth of messages. The breadth could be measured by the numbers of messages posted for a certain discussion topic, and the depth can be configured by how the hierarchical relationship of the messages is. For example, a patient support community has broad shallow threads of messages. In contrast, a scholarly discussion community that focuses on factual and on-task interaction probably shows narrow deep threads of posts. In addition, Abedin, Daneshgar, and D'Ambra (2011) defined sense of interactivity as the individual perception of discussion depth (i.e., whether the other online learners in a CSCL community actively respond to a particular point of view). Abedin et al. (2011) investigated how sense of interactivity promoted online students' collaborative learning outcomes, finding that sense of interactivity with other four social factors (i.e., "finding help", "sense of appealing", "sense of boringness", and "sense of frustration") predicted perceptions of pedagogical effectiveness of CSCL. Likewise, other research confirmed the positive effect of interactivity on online collaborative learning, finding that interactivity promotes

positive emotions, such as trust, belonging, good working relationship, learning satisfaction, and thus facilitates online leaners' learning performance in CSCL(Cho et al., 2007; Hsu, 2008; Kreijns et al., 2007).

Integrating the above conceptualization of interactivity and associated research findings, we know online learners in highly interactive online learning communities tend to feel at ease since they feel supported, pleasant, and interested in interacting with the others. Moreover, with sense of ease, individuals are more likely to have positive expectation of online learning outcomes and thus are more willing to communicate with the other online learners.

Senses of Self- and Collective Efficacy

Once individuals feel at ease while using technology and interactivity in CSCL communities, they will be more confident in achieving CSCL goals. This confidence can be represented as self-efficacy. Albert Bandura (1977) theorized about the concept of self-efficacy based on the social cognitive theory which states that observational learning and social experience play important role in the cognitive development of human beings (Ormrod, 2011). That is, people observe others' performing behaviors within a social context and associated consequences to guide their own performance. Based on this epistemological perspective, Bandura (1986) defined self-efficacy as the beliefs of one's capabilities and outcomes of efforts on behaviors and thus believed that self-efficacy determined one's choice, efforts, persistence and perseverance, and degree of anxiety or serenity on performing behaviors.

In addition, Bandura (1997) hypothesized four primary sources that jointly influenced people to form self-efficacy on their behaviors, though people's interpreting

and weighting the four sources were affected by many other factors, such as gender, culture, ethnicity, academic background etc.. The four sources influencing self-efficacy are mastery experience, vicarious experience, verbal and social persuasions, and emotional and physiological states. Mastery experience refers to people's judgement and evaluation of their previous competence on academic practices, which has been demonstrated as the most predictive source of self-efficacy across domains and populations (Britner & Pajares, 2006; Klassen, 2004; Pajares, Johnson, & Usher, 2007; Usher & Pajares, 2006a, 2006b). In addition to mastery experience, people gauge their academic capabilities via vicarious experience (i.e., observing social models' endeavors and behavioral consequences). The models could be classmates, family members, famous people who struggle through problems but finally reach success (Schunk & Hanson, 1985, 1989), and even television or movie stars who do not have similar lives with others (Bandura, 2004). However, a significant strong correlation between vicarious experience and self-efficacy was not always found in empirical research (Usher & Pajares, 2008). It was inferred that other contextual factors probably mediate the influence of vicarious experience on self-efficacy (Usher & Pajares, 2008). The third source is verbal and social persuasions, which refers to the evaluative feedback from parents, teachers, and peers on people's academic capabilities. Bandura (1997) believed in reality, social persuasion was more powerful to undermine people's self-efficacy than to enhance it. In the meta-analysis of Usher and Pajares (2008), social persuasion was significantly correlated with self-efficacy in many empirical studies though it did not predict self-efficacy across all contexts when included in regression analyses. At last, emotional and psychological state, such as anxiety, fatigue, stress, etc.,

provide other clues for people to evaluate their capabilities on academic tasks and they were demonstrated as negatively predictive to self-efficacy (Johnson, 2005; Klassen, 2004; Usher & Pajares, 2006a, 2006b).

The four sources are highly correlated with one another to influence self-efficacy (Usher & Pajares, 2008). Given the four intertwined sources of self-efficacy, especially the strong relationship between social persuasions and physiological states (Usher & Pajares, 2008), we can deduce when one's anxiety gets relieved from smooth interaction in an online collaborative learning community, his or her self-efficacy is more likely to be boosted on achieving learning goals. The relief of anxiety can be derived from receiving positive feedback, feeling friendship with others, using online learning technology smoothly, and so on. With boosted self-efficacy, online learners show preference on CSCL so tend to engage in online group activities (Wang & Newlin, 2002), and apply more high-level cognitive skills or learning strategies in online group activities, such as analysis, synthesis, evaluation, elaborative feedback, critical thinking, etc. (Wang & Lin, 2007; Wang & Wu, 2008; Wilson & Narayan, 2016).

In addition, individual self-efficacy in group learning contributes to collective efficacy (Wang & Lin, 2007). Collective efficacy is defined as the belief on capabilities of a group as a whole to achieve designed learning goals, and influences group-level investment of effort, persistence, and group achievement (Bandura, 1997; Bandura, 2000). The contribution of individual self-efficacy to collective efficacy is due to that individually positive self-evaluation on academic capability can function as a positive vicarious experience for others. In online collaborative learning communities, learners

show similarities on learning plans, tasks, and goals so they are likely to estimate their own academic capabilities based on others' performing consequences. In this case, individuals' positive self-efficacy as a whole indicates group-level confidence on collaboratively achieving online learning goals. Reversely, positive collective efficacy promotes active discussion behaviors and group performance in CSCL communities (Wang & Hwang, 2012; Wang & Lin, 2007).

Adaptation to Group Regulation

In CSCL communities, adaptation to group regulation refers to the process where individuals would like to accept group's regulation on achieving collaborative learning goals and adjust individual learning to group learning. In CSCL communities, various instructional interventions about regulating diversely individual learning into a unified form have been explored and widely applied to CSCL. Moreover, positive impact of the instructional interventions on interpersonal relationship in CSCL environments has been confirmed. For example, collaborative summarization is one of the instructional interventions. Group members in CSCL communities follow a script that specifies the sequence of interaction to justify and synthesize divergent ideas into a shared knowledge understanding or problem solution (Fiorella & Mayer, 2015; Frank Fischer et al., 2013; Peterson & Roseth, 2015; Strijbos & De Laat, 2010). This instructional intervention promotes group connection since it focuses learners' attention to task-related learning materials and interaction (McDonald, Larson, Dansereau, & Spurlin, 1985; Schoonenboom, 2008; Strijbos, Martens, Jochems, & Broers, 2004; Walther & Bunz, 2005; Weinberger et al., 2005; Weinberger, Stegmann, & Fischer, 2010; Yager, Johnson, & Johnson, 1985; Zahn, Krauskopf, Hesse, & Pea, 2012). It is

noteworthy that the script just regulates group members' performance in CSCL, but it does not necessarily sacrifice individual diversity. The shared understanding or problem solutions that group learners agree on do not attribute to a certain individual who leads CSCL, but to a synthesis of diversely individual perspectives.

Efforts for Group Consensus

In a cohesive CSCL, individual efforts for group consensus refers to that individuals commit to explain and elaborate their knowing and views, and comment on others' ideas, since they believe the effort can contribute to group consensus on knowledge construction or decision making, especially during complex problem solving (Janssen, Erkens, Kanselaar, et al., 2007). Herein, the group consensus is conflict-oriented, which means that individuals continuously refine knowledge construction or problem solutions via active interaction, instead of simply accepting peers' ideas or taking over partners' perspectives (Weinberger & Fischer, 2006).

However, the desired conflict-oriented interaction does not happen automatically (Janssen, Erkens, Kanselaar, et al., 2007; Kreijns et al., 2003; Liaw & Huang, 2000). In many cases, online learners neither argue with the others (Kuhn & Udell, 2003; Munneke, Andriessen, Kanselaar, & Kirschner, 2007) nor offer explanation for their ideas (van der Meijden & Veenman, 2005). Educators and researchers have widely discussed the causes of low participation rate from the dimensions of learners, instructors, and interaction media. Some online learners dominate group activities (Savicki, Kelley, & Ammon, 2002) so that others cannot equally participate in CSCL. Instructors take for granted that CSCL environments make social interaction possible and thus neglect associated instructional interventions

(Kreijns et al., 2003). In addition, some CSCL environments lack medium richness to facilitate communication, for example, only incorporating text-based chat into CSCL environments (Mennecke, Valacich, & Wheeler, 2000).

Various tools of visualizing online group learners' cognitive processes, as one of instructional interventions on conflict-oriented interaction, are embed in CSCL interfaces for learners to compare knowledge states, problem solutions, discussion progress, and other associated cognitive processes among them. The visualization of cognitive process triggers continuous and efficient online interaction towards knowledge construction because it provides a clear clue for individual learners to identify group knowledge gap or divergence on knowledge understanding and problem solution (Bodemer, 2011; Dehler, Bodemer, & Buder, 2007; Dehler, Bodemer, Buder, & Hesse, 2011; Sangin, Molinari, Nüssli, & Dillenbourg, 2011; Schreiber & Engelmann, 2010). In this case, the clued interaction makes group learners know each other better and help to reach group consensus on knowledge understanding and problem solving. The positive effect of the instructional intervention suggests that during the process of reaching conflict-oriented consensus, individuals deeply know and interact with one another in CSCL communities and thus a cohesive relationship among group learners is more likely to be set up.

Sense of Leadership to Group Learning

Sense of leadership to group learning fulfill online leaners' need of autonomy and thus motivate their contribution to CSCL (Deci & Ryan, 2000). Leadership arises from one or combination of the factors: 1) the need to display physical power, 2) psychoenergetic superiority, 3) higher abilities in macromanagement, 4) higher abilities

in specialized tasks 5) higher abilities in executing tasks, 6) higher spiritual status (Trevisani, 2015). In a CSCL community, teaching presence can generate sense of leadership, because it aims at motivating interaction, executing specialized tasks, and managing overarching goal achievement (Trevisani, 2015). Teaching presence is primarily provided by instructors in learning communities (Garrison, Anderson, & Archer, 1999). In CSCL environments, students cannot always get immediate guidance from instructors as much as they do in traditional classroom (Azevedo et al., 2004; de Jong et al., 2005). Hence, online learners inevitably play the role of instructors, building understanding (such as stimulating participation, reinforcing contribution, orienting discussion to facilitate knowledge acquisition) and providing direct instruction (such as presenting question, confirming understanding, and summarizing discussion) (Garrison et al., 1999). In this case, the leadership that instructor should have present is transferred to students in part. This transfer meets group members' need of autonomy (i.e., one's universal urge to realize his or her own career goal and act in harmony with his or her integrated self) (Jang, Reeve, & Deci, 2010; Reeve, 2006; Ryan & Deci, 2000).

For building understanding, online learners are usually assigned, or they volunteer to lead different phases of task-related interaction to provide the teaching presence, such as starter, source researcher, discussion moderator, theoretician, summarizer, topic reviewer, and so on. Performing the roles, online leaners undertake more explicit and concrete responsibilities in group learning (De Wever, Van Keer, Adler, & Valcke, 2007; De Wever, Van Keer, Schellens, & Valcke, 2009; Schellens, Keer, & Valcke, 2005; Strijbos, De Laat, Martens, & Jochems, 2005; Zhu, 1996). For providing direct instruction, online learners are required to provide constructive

explanatory peer feedback or assessment, during which providers perceive concrete responsibilities to discern and analyze others' ideas, diagnose misunderstandings, and bring in extra knowledge from other resources (Garrison et al., 1999). At present, instructional intervention about peer feedback or assessment have been widely used in CSCL environments, which effectively promotes individual learning gain, group members' knowledge verification, questioning, negotiation, and efficiency of collaborative problem solving (Buder & Bodemer, 2007; Kimmerle & Cress, 2007; Kirschner, Kreijns, Phielix, & Fransen, 2015; Phielix, Prins, & Kirschner, 2010; Phielix, Prins, Kirschner, Erkens, & Jaspers, 2011). These promoted activities may get group learners know each other better and make emotional connection among them possible.

Benefitting from Diverse Resources

Benefitting from diverse recourses fulfills online leaners' need of competence (Deci & Ryan, 2000). According to McMillan & Chavis (1986)'s theory, in physical communities, people are likely to be attracted by the members whose knowledge or skill set can benefit them. In CSCL communities, peers' diversity in ideas, experiences, expertise, and cognitive processes, as benefits or attractions, can initiate interaction-based meaning making process (Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen, 1999; McConnell, 2000; Roberts, 2004). Hence, heterogeneous grouping, which means composition of individuals with diverse cognitive experiences, is advocated to improve interpersonal connection among group learners (Hooper & Hannafin, 1991).

In CSCL communities, heterogeneous grouping is an instructional intervention in which instructors compose group learners from multidisciplinary backgrounds or assign different roles to group learners. This group formation effectively stimulates deep understanding, active discussion, and knowledge construction due to exposing online learners to multidisciplinary knowledge (Veerman & Veldhuis-Diermanse, 2001; Veldhuis-Diermanse, 2002). Grouping individuals with different initial beliefs on problem solving is another heterogeneous group composition, which helps to clarify misunderstanding and build shared knowledge understanding and problem solutions (Convertino, Billman, Pirolli, Massar, & Shrager, 2008). In addition, grouping low- and high- ability students can motivate their participation in CSCL. Research have demonstrated that this group composition promotes interaction and efficiency of learning goal achievement, particularly for the low-ability students, though the positive effect may be offset by high-ability students' reduced academic efficiency (Hooper & Hannafin, 1988, 1991). To sum up, exposing to diverse disciplinary backgrounds, initial beliefs on problem solving, and academic ability, group learners may challenge and update their existing knowledge structure and thus their need of competence can be satisfied (Ryan & Deci, 2000).

Benefitting from Homogeneous Value

Benefitting from diverse recourses fulfills online leaners' need of relatedness (Deci & Ryan, 2000). Individual values originate from culture, society, and family where people live, which determine what emotional and intellectual needs people have and how people attend to them (McMillan & Chavis, 1986; Rokeach, 1973). In CSCL communities, individual values also provide a reference for online learners to decide

what is good, desirable, and important and thus determine their behaviors and choices. Hence, with similar socio-cultural background, learners probably have similar needs, priorities, and learning goals to reach, and thus are more likely to be tied with one another. Feeling connected to others in CSCL communities fulfills online learners' need of relatedness (Ryan & Deci, 2000)

Pfeil, Zaphiris, and Ang, (2006) compared the editing patterns of web users from French, German, Japanese, and Dutch on one article of Wikipedia. Meanwhile, the researchers attempted to explore the relationship between the editing patterns and cultural values on power distance, individualism, masculinity, and uncertainty avoidance. Their finding indicated that the French were more willing to follow orders and powerful people as well as reluctant to declare others' incorrect opinions; the Japanese with lower individualism index, higher masculinity, and uncertainty avoidance indices were more willing to add and clarify information and eliminate uncertainties. However, the Dutch contributed a lot in information clarification though they had high individualism index. Likewise, Kim and Bonk (2002) revealed cross-cultural differences in participants' online collaborative behaviors in two interconnected conferences. The researchers found that American students were more engaged in seeking results or solutions; Finnish students exhibited a higher level of reflection and monitoring group efforts; Korean students were more willing to share personal feelings or concerns at the beginning of the virtual conference and they were not as task-oriented as the other two groups of students. These studies explain why incorporation of cultural diversity in CSCL environments always indicated negative effect on equal participation, peer engagement, and intercultural communication in some empirical research. It is

because difference on language, communication tool use, prior online learning experience, preference of communication pattern etc. blocks online learners' connection. (Anakwe, Kessler, & Christensen, 1999; Hannon & D'Netto, 2007; Kim & Bonk, 2002; Liu, Liu, Lee, & Magjuka, 2010; Tapanes, Smith, & White, 2009).

Even so, we should not ignore the potential benefits from diverse culture for CSCL. The cultural diversity can bring in multi-dimensional understanding and perspectives and thus promotes collaborative knowledge construction. On the other hand, in current online education, the involvement of participants from diverse cultural backgrounds becomes increasingly inevitable (Hannon & D'Netto, 2007; Stahl, 2006). Therefore, it is crucial for educators and researchers to explore how to build a cohesive CSCL community with cultural diversity, instead of completely removing it. Some instructional interventions have been proposed, such as accommodating pedagogy and curriculum to students from diverse cultural and language background, balancing the use of local and global learning cases, contextualizing culturally specific examples or cases, and so on (Liu et al., 2010; McLoughlin, 2001; McLoughlin & Oliver, 2000).

Achievability from Contribution to Group Success

Achievability from contribution to group success fulfills the individual need of competence because group learners experience mastery in CSCL (Deci & Ryan, 2000). Fulfillment of the need of competence intrinsically motivates online learners to regulate their future learning process and indicate people's well-being (Deci & Ryan, 2000).

In CSCL communities, group success refers to a productive knowledge construction, which can reflects in any one or mix of four dimensions: participation, epistemology, argument, and social mode of co-construction (Weinberger & Fischer,

2006). Therefore, the individual contribution to the group success in CSCL communities can be multi-dimensional. First, individuals dynamically and equally participate in discourse activities in CSCL (Barab & Duffy, 2000; Cohen & Lotan, 1995; Janssen et al., 2012; Saab, van Joolingen, & van Hout-Wolters, 2011). Second, individuals engage in task-related activities, such as, building shared understanding and applying the shared understanding to solve complex problems (Fischer, Bruhn, Gräsel, & Mandl, 2002; Palincsar, Anderson, & David, 1993; Armin Weinberger, 2003). Third, individuals successfully construct and integrate arguments and counterarguments (Baker, 2003; Leitão, 2000; Spiro, Feltovich, Jacobson, & Coulson, 1991). Fourth, individuals articulate one's own thought, question the others, accept peer opinions or understandings, integrate peers' ideas into theirs, or deny and modify the others' perspectives (Fischer et al., 2002; Teasley, 1997). The four dimensions have different focuses, but suggest a common ground that engaging in a dynamically balanced interaction accounts for the individual contribution to a productive CSCL. Multidimensional contribution to group success leads to achievability. Reversely, the achievability motivates group learners to invest more efforts on their CSCL.

Perception of linkage of individual efforts to group success accounts for the generation of achievability. Reward interdependence is an effective instructional intervention to help individuals to generate the perception of the linkage. Instructors implement this intervention in many ways, for example, through providing bonus points only if all group members attain a pre-set criterion. This instructional intervention can effectively motivate mutual support of group learners in CSCL due to the required linkage of individual efforts to the achievement of group learning goals (Brewer &

Klein, 2006; Lehtinen et al., 1999). In addition, verification of individual contribution to group discussion also triggers individual achievability in CSCL. Visualization of individual participation rate in group discussion is a commonly-used intervention to identify contributors as well as social loafing or free riders (Janssen, et al., 2007). For example, Janssen and his colleagues (2007) used a circle to stand for a learning group and spheres surrounding the circle for individuals in the group. The distances from the spheres to the circle represented the number of messages posted by individuals, and the size of the spheres indicated the number of keystrokes typed by individuals for a group work (Janssen, et al., 2007; Janssen, Erkens, & Kirschner, 2011). The visualization of individual participation rate effectively increased equal participation, coordination, and regulation activities (Janssen, et al., 2007; Janssen et al., 2011; Jongsawat & Premchaiswadi, 2009; Kimmerle & Cress, 2007; Michinov & Primois, 2005; Phielix et al., 2011). To sum up, the reward interdependence and visualization of individual participation rate, functioning as verification feedbacks for individual learners, confirm whether they engage in CSCL to achieve online learning objectives. The consequence of the verification feedbacks is that individual learners become more motivated to participate in CSCL due to their achievability (Coll, Rochera, & de Gispert, 2014; Coll, Rochera, de Gispert, & Díaz-Barriga, 2013). However, the verification feedback cannot exclusively satisfy students' need of achievability at each phase of CSCL, because sometimes online learners need more elaborative feedbacks and instructors have to tailor their feedback according to the change of needs (Coll et al., 2014; Coll et al., 2013). Elaboration feedback does not only aim at verifying whether students achieve in a CSCL, but also at improving students' learning strategies or scaffolding students'

learning based on their progress in the CSCL (Coll et al., 2014; Coll et al., 2013; Espasa & Meneses, 2009). Improvement of learning strategies and scaffolding further satisfies learners' need of experiencing mastery (Ryan & Deci, 2000) and thus leads to achievability. This may account for why elaborative feedbacks promote more constructive discussions and students' satisfaction with their CSCL (Alvarez, Espasa, & Guasch, 2012; Espasa & Meneses, 2009).

Cognitive Awareness

Group awareness helps remove sense of isolation and drives emotional connection among online learners (Abedin et al., 2010; Abedin, et al, 2011), which is divided into cognitive awareness and social awareness (Dehler, Bodemer, Buder, & Hesse, 2011; Janssen, Erkens, & Kirschner, 2011). Cognitive awareness pertains to that individuals get aware of others' cognitive information about CSCL, such as individual knowledge structure and group knowledge distribution. In CSCL communities, cognitive awareness is a pedagogical intervention, leading to active interactions and efficient group learning (Bodemer, 2011; Dehler, Bodemer, & Buder, 2007; Dehler et al., 2011; Engelmann, Tergan, & Hesse, 2010; Molinari, Sangin, Nüssli, & Dillenbourg, 2008; Sangin, Molinari, Nüssli, & Dillenbourg, 2011; Schreiber & Engelmann, 2010).

Dehler and her colleagues (2011) incorporated a communication tool named as *Knowledge Awareness Visualization* into a CSCL interface to facilitate cognitive awareness between dyad learning partners. Read a hypertext about immune system was the learning task. In the communication interface, two boxes alongside each paragraph of the hypertext were assigned to the dyad learning partners. After reading each paragraph, the learning partners self-assessed their understanding via clicking their own

boxes to color them green to indicate sufficient understanding or leaving it blank to show deficient understanding. When the dyad learning partners discussed their reading comprehension, the colored boxes were represented to provide clues for them to ask questions and explain misunderstanding. As a result, representation of understanding status increased communication among learning partners. In addition, the clued interaction deepened learning partners' mutual awareness on cognitive processes so that they are more likely to get connected emotionally. Many other similar communication tools were applied to CSCL, such as *Collaborative Integration Tool* (Bodemer, 2011), *Complex Concept Mapping* (Engelmann, et al, 2010), *Cmap* (Molinari et al., 2008; Schreiber & Engelmann, 2010) etc., which all enhanced cognitive information sharing and thus promoted emotional connection among group leaners.

In addition, peer feedback is another instructional intervention to increase cognitive information sharing among online group learners. In CSCL communities, peers are required to provide feedback on collaborative learning outcomes or processes of performing group work (Phielix et al., 2010, 2011). To provide helpful peer feedback, providers must be aware of receivers' cognitive processes about how their task-related ideas, actions, and strategies are generated. Hence, peer feedback lead to lower conflict level in online discussion and positive attitude towards collaborative problem solving (Phielix, et al., 2010). However, exclusively providing peer feedback cannot positively change individual or group performance in CSCL. Feedback receivers are required to reflect on their own performance and communicate with providers to determine whether peer feedbacks provide appropriate clues for them to reach a better understanding (Phielix, et al., 2010). Hence, feedback reflection further focuses group

learners' attention over their own and others' cognitive processes so further enhances mutual awareness among group learners.

Social Awareness

Social awareness refers to being aware of group learners' participation rate and participation quality, such as group members' number of messages sent in online discussion board and debate status in online discussion, (Janssen, et al., 2007, 2011; Jongsawat & Premchaiswadi, 2009; Kimmerle & Cress, 2007; Michinov & Primois, 2005; Phielix et al., 2011) as well as social traits such as friendliness, cooperation willingness, trust, novelty, etc. (Buder & Bodemer, 2007; Phielix et al., 2010, 2011).

In the study of Janssen et al. (2007), *Participation Tool* was utilized to visualize participation rate in a CSCL community (i.e., showing the amount of messages that each group learner contributed to his or her group's online communication). The results showed that treatment groups engaged more in coordination and regulation of social activities. The more coordination and regulation activities increased the shared events ending with positive consequences, so the group learners are more likely to get emotionally connected with one another in the CSCL community. Likewise, *Shared Space*, a more advanced communication tool, was implemented in the study of Janssen, et al. (2007) to overcome communication problems and stimulate deep interaction in a CSCL community. *Shared Space* did not only quantitatively display group learners' participation rate but also qualitatively monitored their agreement and debate status. The findings indicated that the group learners who used this communication tool perceived smoother in online communication; valued critical but constructive online

discussion; had more occurrences of positive group behaviors; perceived effective group's task strategies; and engaged in deeper collaborative learning activities.

For visualizing social traits, Phielix and his colleagues (2011) employed a pentagon diagram to show each group learner's scores on six continuous scales ranging from 0 to 4 (0 =none, 4 = very high): influence, friendliness, cooperation, reliability, productivity, and quality of contribution. Six angles of the pentagon stood for the six scales and the distances from the angles to the center of the pentagon were all four-point stand. Each group learner's self- and peer-assessment scores on the six scales located in the distances, and thus each group learner got two unique pentagons based on the scoring. Meanwhile, each group learner could observe the others' pentagons at any time during the CSCL. The findings indicated that mutual awareness of the social traits facilitated group leaners to improve their corresponding collaborative behaviors over time and become more influential, friendlier, cooperative, and productive. Eventually, group learners made higher-quality contributions to the CSCL. In this case, the group learners might develop emotional connection with one another in the CSCL community.

Conclusion

To sum up, I contextualized McMillan (1996) and McMillan and Chavis (1986)' conceptual framework of the concept of sense community to CSCL environments and accordingly proposed four perceptual constructs (see Table 2). Scaffold by the contextualized four perceptual constructs, I explored eleven instruction-related factors that might influence the four constructs through reviewing the literature in the research field of CSCL. 64 empirical research were selected to demonstrate the positive effect of the factors on online learners' emotional cohesion and productive learning outcomes in

CSCL environments. Eventually, the four perceptual constructs and eleven instruction-related factors formed the two-level theoretical framework of the concept of sense of community in CSCL (see Table 2).

Given the two-level theoretical framework, we know feeling of membership should start with learners' avoidance of isolation and then the want of contribution to group activities; be catalyzed by recognition and acceptance to the contributions; thus, promotes learners' self- and collective efficacy to construct knowledge. The second construct, perception of influence, is a bidirectional psychological process in CSCL community. One process is groups' regulating individuals to generate shared knowledge understanding or problem solutions; the other is individuals' making efforts to propose and elaborate their knowing and ideas to form shared group understanding or decision-making. Third, four factors: sense of leadership to group learning, benefitting from diverse resources, benefiting from homogeneous value, and achievability from contribution to group success, work together to fulfill learners' needs of competence, autonomy, and relatedness and thus strengthen group members' intrinsic motivation to bond closely with one another in CSCL environments. Eventually yet importantly, emotional connection is driven by cognitive awareness and social awareness. The awareness refers to the situation that group learners are mutually aware of one another and care about what happens in CSCL communities, which is the preposition for online learners to generate emotional connection.

Table 2

Two-Level Theoretical Framework of the Concept of Sense of Community in CSCL

Perceptual Constructs	Instruction-Related Factors	Empirical Evidence

Feeling of Membership	Close Socio-Emotional Relationship: Learners get along well with others	• Cho et al., 2007 • Flowers, 2015 • Wang, 2009
	Sense of Ease: Learners perceive at ease in an online learning community	• Selim, 2007 • Volery & Lord, 2000 • Liu et al., 2010 • Liaw, 2008 • Abedin et al. 2011 • Cho et al., 2007 • Hsu, 2008 • Kreijns et al., 2007
	Senses of Self- and Collective Efficacy: Learners feel that they are capable to achieve individual and group learning goals	• Wang & Hwang, 2012 • Wang & Lin, 2007 • Wang & Newlin, 2002 • Wang & Wu, 2008 • Wilson & Narayan, 2016
Perception of Influence	Adaptation to Group Regulation: Learners are willing to accept group regulation on achieving collaborative learning goals	• McDonald et al., 1985 • Schoonenboom, 2008 • Strijbos et al., 2004 • Walther & Bunz, 2005 • Weinberger et al., 2005 • Weinberger et al., 2010 • Yager et al., 1985 • Zahn et al., 2012
	Efforts for Group Consensus: Learners commit to explain and elaborate their knowing and views and comment on others' ideas in order to reach group consensus	• Bodemer, 2011 • Dehler et al., 2007 • Dehler et al., 2011 • Sangin et al., 2011 • Schreiber & Engelmann, 2010
Fulfillment of Needs	Sense of Leadership to Group Learning: Learners feel leadership through performing following activities	
	• Building understanding: Learners choose their preferred role to lead different phases of task-related interaction	• De Wever et al., 2007 • De Wever et al., 2009 • Schellens et al., 2005 • Strijbos et al., 2005 • Zhu, 1996
		• Buder & Bodemer, 2007

• Direct instruction: Learners provide constructive explanatory feedback or assessment to others' work using related expertise	• Kimmerle & Cress, 2007 • Kirschner et al., 2015 • Phielix et al., 2010, 2011
Benefitting from Diverse Resource: Learners experience mastery while exposing to the following things	
• Multidisciplinary knowledge	• Veerman & Veldhuis-Diermanse, 2001 • Veldhuis-Diermanse, 2002
• Different initial beliefs on problem solving	• Convertino et al., 2008
• Other learners with higher competence	• Hooper & Hannafin, 1988, 1991
Benefitting from Homogeneous Value: Leaners feel relatedness when having similar needs, priorities, and goals with others to reach in CSCL	• Anakwe et al., 1999 • Hannon & D'Netto, 2007 • Kim & Bonk, 2002 • Liu et al., 2010 Tapanes et al., 2009
Achievability from Contribution to Group Success: Learners feel achievability through following activities	
• Reward interdependence	• Brewer & Klein, 2006 • Lehtinen et al., 1999
• Visualization of learners' participation	• Janssen et al., 2007 • Janssen et al., 2011 • Jongsawat & Premchaiswadi, 2009 • Kimmerle & Cress, 2007 • Michinov & Primois, 2005 • Phielix et al., 2011
• Presentation of elaboration feedback	• Alvarez, 2012 • Espasa & Meneses, 2009

Emotional Connection	Cognitive Awareness: Leaners feel emotionally connected with others through sharing following cognitive information	
	• Prior knowledge structure and group knowledge distribution	• Bodemer, 2011 • Dehler et al., 2007 • Dehler et al., 2011 • Engelmann, et al, 2010 • Molinari, et al, 2008 • Sangin et al., 2011 • Schreiber & Engelmann, 2010
	• Peer feedback	• Phielix et al., 2010, 2011
	Social Awareness: Leaners feel emotionally connected with others through following information	
	• Participation rate and quality	• Janssen et al., 2007 • Janssen et al., 2011 • Jongsawat & Premchaiswadi, 2009 • Kimmerle & Cress, 2007 • Michinov & Primois, 2005 • Phielix et al., 2011
	• Social traits	• Janssen, 2007 • Phielix et al., 2010, 2011

Chapter 3: Pilot Study

In Chapter 2, I proposed a two-level theoretical framework for the concept of sense of community in CSCL environments based on a comprehensive literature review. The first level is perceptual level containing four constructs. The other is instruction-related level containing eleven factors that could influence the constructs. In Chapter 3, I will use this two-level theoretical framework as a measurement model to start the new *SoC in CSCL* instrument development. Chapter 3 is a pilot study for validating the new instrument. The purpose is to answer the research question 2: how the literature-review-supported measurement model was supported by statistical evidence.

General Study Procedure

To provide the validity evidence, I created an instrument with 60 eight-point Likert-type items using the literature-review-supported measurement model to assess online leaners' sense of community in CSCL environments (SoC in CSCL). I distributed the first instrument version using Qualtrics, an online instrument management website, to the students who were taking online course(s) at a major university in the Midwestern section of the United States. Individuals' responses to the items were submitted to Exploratory Factor Analysis (*EFA*) and Confirmatory Factor Analysis (*CFA*) to provide validity evidence for the measurement model underlying the *SoC in CSCL* instrument.

The First *SoC in CSCL* Instrument Version

Based on the two-level theoretical framework, 60 Likert-type items were drafted as the first *SoC in CSCL* instrument version. Specifically, considering the perceptual and instruction-related levels of the theoretical framework, I tried to design item

statements to literally involve the perceptual and instruction-related information. For example, *Item 4* fell into the *Feeling of Membership* construct and the *Sense of Ease factor* (see Table 3). I drafted the statement for this item as "The communication interface in the online course is user-friendly". Feeling of user-friendly was the perceptual information. Communication interface was related to instructional technology used for online courses.

The first instrument version contained four perceptual constructs derived from the literature review: *Feeling of Membership*, *Perception of Influence, Fulfillment of Needs*, and *Emotional Connection*. Each construct was concerned with two to four instruction-related factors (see Table 3). Directions at the beginning of the instrument stated, "Please indicate how much you agree or disagree with each statement by clicking on the response that corresponds with your previous online learning experience" (see Appendix A). Next, the possible responses to each item were provided, including "strongly disagree (1)", "moderately disagree (2)", "somewhat disagree (3)", "slightly disagree (4)", "slightly agree (5)", "somewhat agree (6)", "moderately agree (7)", and "strongly agree (8)" (see Appendix A).

Before data collection, the instrument was revised based on the advice of students who had online learning experience. The advice primarily referred to the readability of the items on assessing online leaners' sense of community in online learning communities. Specifically, I met with students who were taking online courses and showed them the instrument draft. The students read the draft and suggested item revisions based on their online learning experience. For example, in the instrument draft, *Item 30* stated "My online classmates' diverse thoughts and understanding can

remove my initial bias in the online course". One student pointed out that "bias" was confused because this word usually refers to prejudice in favor of or against someone or something in an unfair way. Based on the student's online learning experience, the bias hardly happened in his online course, so he recommended replacing this word with "misunderstanding". The replacement made the statement more understandable to online learners, so I accepted the replacement.

Table 3

The First SoC in CSCL *Instrument Version*

Perceptual Constructs	Instruction-Related Factors	Item N	Item Examples
Feeling of Membership *(FM)*		15	
	• Close Socio-emotional Relationship *(SR1-SR3)*	3	My classmates in the online course are friendly.
	• Sense of Ease *(E1-E6)*	6	The communication interface in the online course is user-friendly.
	• Senses of Self and Collective Efficacy *(EF1-EF6)*	6	I am certain that I am doing well in the online course
Perception of Influence *(PI)*		6	
	• Adaptation to Group Regulation *(A1-A3)*	3	My classmates help focus my attention to learning tasks
	• Efforts for Group Consensus *(CE4_CE6)*	3	I am clearly aware of my role in an online collaborative learning
Fulfillment of Needs		27	

(FN)	• Sense of Leadership to Group Learning *(L1-L6)*	6	I could benefit from the diverse experiences of my classmates in the online course
	• Benefitting from Diverse Resources *(DB1-DB6)*	6	I have a similar learning style as my classmates in the online course
	• Benefitting from Homogeneous Value *(HB1-HB3)*	3	I enjoy discussing with my classmates in the online course
	• Achievability from Contribution to Group Success *(AC1-AC12)*	12	The professor's feedback is important for me to evaluate my individual/group online learning achievement
Emotional Connection *(EC)*		12	
	• Cognitive Awareness *(C1-C6)*	6	I know the knowledge gap of my group
	• Social Awareness *(S1-S6)*	6	I care about how the other members evaluate my works

Participants

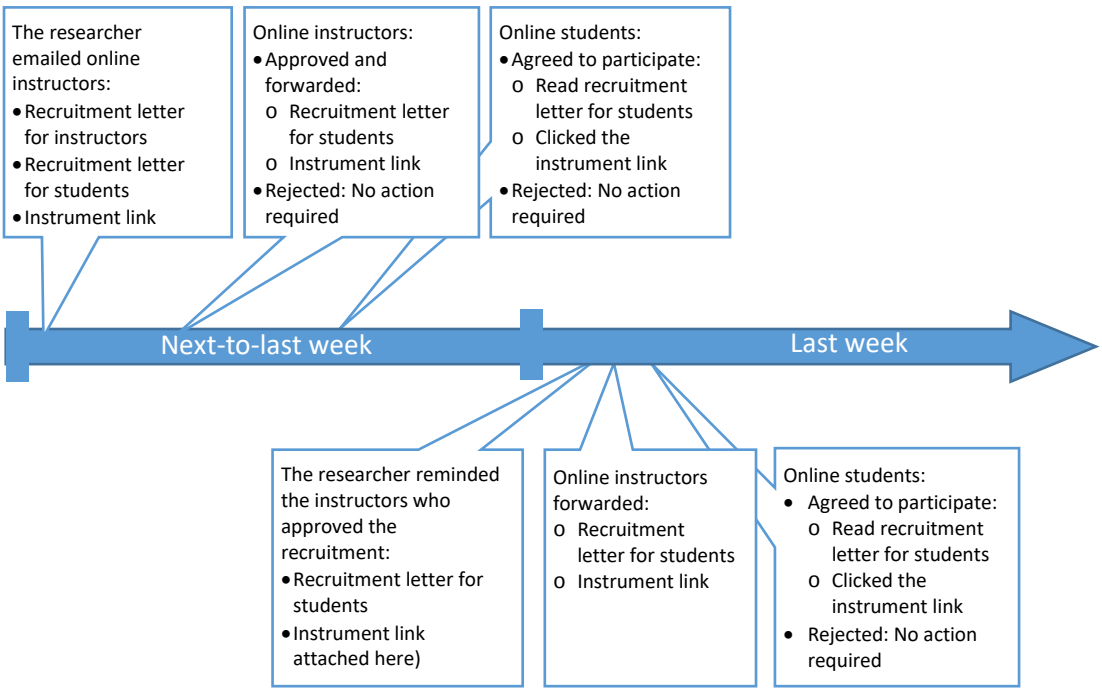
Instructors teaching online courses in summer and fall semesters of 2016 at a major university in the Midwestern section of the United States were first identified for possible participation. The course enrollment webpage of the university provided detailed information about online courses to easily identify the subject, course number, credit hours, enrolled term, meeting time, the number of enrolled students, and the contact information of instructors. I extracted the online courses' meeting time and instructors' email addresses from the online course enrollment webpage to recruit

online students. Online students taking online classes were recruited via contacting their instructors.

In total, there were 850 online courses identified in the two semesters but not all course ended at the same time during the semesters. The data collection started in the next-to-last week of each online course when students were expected to have had full communication with one another to develop the sense of community to their online courses (see Figure 1). Recruitment emails were sent to online courses' instructors to get approval for recruiting their students in the next-to-last week of the targeted online courses and one reminder were sent to the instructors in the last week of the courses. In the email to the instructors, two recruitment letters were attached. The first letter addressed instructors and was designed to help them understand the purpose of the study and the recruitment procedure (see Appendix C). The second was for instructors to forward to their students to help them learn how they would participate in this study if they chose to participate (see Appendix D). The online instrument link was attached to the recruitment letter for students. Instructors who agreed to allow their students to participate forwarded the second recruitment letter to their online students. The students who received the letter and were willing to participate in this study clicked the attached instrument link. Opening the first webpage for the online instrument, the students read the *Consent Form* (see Appendix F) to learn detailed information about this study. After that, they decided whether or not to participate in the study via clicking "I agree to participate" or "I do not want to participate" at the bottom of the *Consent Form* webpage. Clicking "I agree to participate" lead them to the demographic part of the

online instrument (see Appendix A) and "I do not want to participate" lead them to the end message of the online instrument (see Appendix A).

Figure 1. The Procedure for Recruiting Online Students for the Pilot Study



Eventually, 206 students who were taking online courses in summer and fall semesters of 2016 at a major university in the Midwestern section of the United States participated in this pilot study. The students came from different programs and academic units at the university. Among the students, there were 46 males, 159 females, and 1 other. The group of 16-25-year-old students dominated the participants, accounting for around 45% of the sample. One hundred fifty-four participants were enrolled full-time students and 51 were enrolled part-time students. 93.2% of students had online learning experience before their current online courses. 88% students reported being satisfied with their current learning experience. Over 90% students reported "Yes" on the question about whether they participate in online discussion

and/or group work though these activities were not required by their instructors; moreover, on average, each student reported spending 43.84% of online class time on discussion and/or group work.

Methods and Results

I utilized SAS to analyze the data to answer how the measurement model of the new *SoC in CSCL* instrument proposed by the literature review in Chapter 2 was supported by statistical evidence. First, I sequentially submitted the observed instrument data to *CFA*, *EFA* and again *CFA*. Use of the combination of *EFA* and *CFA* to explore the theoretical framework of a new concept has a long history, especially in the field of psychometric literature (McArdle, 1996; McDonald, 1985). Second, after the measurement model underlying the instrument was defined, Cronbach's Alpha and Omega reliability coefficients were computed for the whole instrument, its underlying perceptual constructs and instruction-related factors to indicate the internal consistency of the *SoC in CSCL* instrument.

Combination of EFA and CFA

CFA. I submitted the observed data to *CFA* using bi-factor model to confirm the proposed measurement model. First, according to the literature review, a two-level measurement model was proposed. The perceptual level that contained four constructs was based on McMillan and Chavis (1986) and McMillan (1996)'s four-construct framework for the concept of sense of community. Referring to the framework and empirical research in the field of CSCL, I proposed eleven instruction-related factors that could influence the four perceptual constructs to form the other level of the measurement model. I hypothesized that these instruction-related factors can account

for additional variances of online learners' sense of community in CSCL environment. Second, using *CFA,* I respectively fit the refined measurement model with hierarchical model and bi-factor model, and found bi-factor model that had more free parameters obtained relatively better model fit than the hierarchical model that had fewer (see Table 4). In addition, I did a *Chi Square Difference Test* to investigate whether the improved model fit was significant. The result showed significance for the improvement ($\Delta\chi 2 = 1737.677$, $\Delta df = 58$, $p<.001$), which means that adding more constraints significantly improved model fit. Third, technically, bi-factor modeling can investigate both an overarching construct that explains most of the variance in the observed data and multiple independent factors that account for some additional variance at the same time (Reise, 2012).

Results. Therefore, bi-factor modeling was utilized here to confirm the refined measurement model. However, poor model fit was found ($\chi^2 = 4186.937$, $df = 1646$; *RMSEA* = .087, *CFI* = .759, *TLI* = .736).

Table 4

Comparison of Hierarchical Modeling and Bi-Factor Modeling

	χ^2	*df*	*R*	*C*	*T*
Hierarchical model	5	1	.1	.5	.5
Bi-factor model	4	1	.0	.7	.7

EFA. Given the poor model fit, I submitted the observed data to EFA to identify and revise poorly designed instrument items. *EFA* can be used to isolate distinct factors and statistically show item coherence (Comrey & Lee, 1992). To be specific, I conducted the *EFA*, using Maximum Likelihood (*EFA-ML*) estimation and allowing the

eleven factors to correlate with the Promax rotation, in which I investigated solutions of the factors fixed from one to eleven. For all fixed solutions, I compared the pairs of the Akaike Information Criterion (*AIC*) (Akaike, 1974) and Schwartz (1978)'s Bayesian Information Criterion (*BIC*) to determine the appropriate solution for the factors underlying the first instrument version. Usually, the most appropriate factor solution occurs when both the *AIC* and the *BIC* indices stop decreasing dramatically as the solution increases from one to eleven. However, compared with *AIC* index that always continues to go down, *BIC* is more likely to identify the approximately correct factor pattern (Preacher, Zhang, Kim, & Mels, 2013). Hence, in this pilot study, I paid more attention to the *BIC* index than the *AIC* index to decide the most appropriate factor solution.

Given the appropriate number of factors, I utilized three criteria to make the theoretical factor structure consistent with the statistically-decided factor solution. First, I deleted the items of which factor loadings were less than .40 across all factors (Stevens, 2002). Factor loading refers to how much an item can be explained by a factor, which can range from -1 to 1. If the factor loading of an item is close to -1 or 1, it means the factor strongly affects the variance in the item. For the first criterion, the cutoff value of .40 stipulated a principle that 40% of item variance explained by an associated factor suggested a strong influence (Stevens, 2002). Hence, the items with factor loadings greater than .40 should be kept and the ones with factor loadings less than .40 should be deleted or revised. For the first instrument version, the main purpose of revision was to shorten the instrument, so I deleted the items that did not saliently load on any of the factors. Second, I also considered the rationality of the item

coherence based on the literature review to delete items or factors (Hindman, Pendergast, & Gooze, 2016), because statistical results should not exclusively serve as the guidance for instrument development. Third, I only kept the factors having three or more than three salient items to assure a statistically meaningful estimation of latent factor scores (Hindman et al., 2016). The revision of the measurement model and instrument items lead to a new *SoC in CSCL* instrument version.

Results. The *EFA* output indicated that there were eight factors underlying the first instrument version because *BIC* indices started to increase after this point (see Table 5). In order to keep the simplicity of the measurement model and shorten the first instrument version, three factors were deleted according to aforementioned three criteria of instrument modification.

Table 5

AIC *and* BIC *Indices for the First Instrument Version*

	Solutions										
	1	2	3	4	5	6	7	8	9	10	11
AIC	6209.219	5432.208	5027.137	4647.625	4373.800	4138.901	3932.397	3786.106	3698.502	3615.235	6209.219
BIC	6608.579	6027.920	5815.873	5626.057	5538.600	5486.741	5459.949	5450.042	5575.494	5661.955	6608.579

First, the *EFA* output indicated 14 items with factor loadings less than .40 across all factors, which means they did not saliently load on any factor, so they were deleted from the first instrument version. The initial deletion lead to the second instrument version (the 46-item version). I re-submitted the data to *EFA-ML*, fixing the number of the factors as eight and allowing them correlated with the Promax rotation. Table 6

showed the item coherence for the second instrument version, where there was no item having factor loading less than .40 across all factors.

Table 6

Factor Loadings for the Second Instrument Version (46 items)

Constructs	Items	Factors							
		F1	F2	F3	F4	F5	F6	F7	F8
Feeling of Membership	SR1	0.01	0.05	-0.07	0.79	-0.22	0.09	0.08	0.05
	SR3	-0.05	0.16	-0.01	0.68	-0.20	0.15	0.00	0.11
	E1	-0.02	0.23	-0.10	0.19	-0.11	0.04	0.01	0.67
	E2	0.09	0.06	0.17	0.20	0.05	-0.04	-0.03	0.55
	E3	0.01	0.28	0.04	0.01	-0.13	-0.04	0.11	0.76
	E4	0.03	-0.19	-0.01	0.83	0.30	-0.03	-0.10	0.07
	E5	-0.04	-0.09	-0.01	0.88	0.18	-0.01	-0.02	0.01
	E6	0.04	0.00	0.02	0.61	0.24	-0.08	0.00	0.01
	EF1	-0.11	0.58	-0.19	-0.14	0.25	0.00	0.13	0.24
	EF2	-0.06	0.57	-0.15	-0.13	0.14	0.02	0.04	0.22
	EF3	0.21	0.50	0.00	0.01	0.02	0.01	0.10	0.05
	EF4	0.10	0.89	-0.01	0.10	0.02	-0.06	-0.09	-0.04
	EF5	-0.05	0.87	0.12	0.23	-0.09	-0.06	-0.08	-0.06
	EF6	-0.16	0.50	0.01	0.29	0.06	0.00	0.17	-0.11
Perception of Influence	A1	-0.05	0.25	0.07	0.17	0.42	0.04	-0.02	-0.01
	A2	0.05	0.17	-0.07	0.38	0.44	-0.06	0.04	-0.14
	CE4	0.02	-0.01	0.00	0.00	0.59	0.01	-0.06	0.00
	CE5	0.05	0.01	0.34	-0.02	0.45	0.08	-0.05	-0.06
Fulfillment of Needs	L1	-0.04	0.62	0.12	-0.14	0.24	-0.01	-0.08	0.01
	L2	0.15	0.48	0.04	-0.06	0.10	0.03	-0.06	0.09
	L3	0.02	0.45	0.40	-0.15	-0.03	0.06	-0.08	0.06
	DB1	0.03	0.17	0.64	-0.01	0.10	0.02	-0.03	0.04
	DB2	-0.02	0.11	0.69	-0.01	0.15	0.10	-0.02	0.00
	DB3	-0.10	-0.13	0.88	-0.05	0.19	-0.01	0.08	0.06
	DB4	0.06	-0.06	0.85	-0.04	0.02	-0.04	0.00	-0.05
	DB5	0.09	-0.17	0.79	0.04	0.13	-0.08	0.09	-0.01
	HB1	0.05	-0.08	0.02	0.04	0.21	0.03	0.63	0.12
	HB2	-0.02	0.00	0.15	-0.05	0.07	0.08	0.73	0.06
	HB3	0.07	0.09	0.24	0.05	-0.03	-0.01	0.63	-0.04
	AC2	-0.03	0.02	0.68	-0.02	-0.22	-0.03	0.10	-0.03
	AC3	0.06	0.20	0.73	0.06	-0.32	0.00	0.05	0.02
	AC4	0.64	-0.05	0.07	0.20	0.09	-0.04	0.01	0.11
	AC5	1.00	-0.06	-0.17	-0.06	0.13	0.10	-0.11	0.09
	AC6	0.92	0.05	0.00	-0.02	-0.01	-0.02	-0.08	0.07
	AC7	0.98	0.11	0.08	-0.01	-0.15	-0.13	-0.01	0.03
	AC8	0.98	-0.01	0.05	0.06	-0.20	-0.05	0.07	-0.06
	AC9	0.69	-0.25	0.04	0.09	-0.01	-0.06	0.25	-0.06
	AC1	-0.08	-0.04	-0.16	0.08	0.04	0.87	0.13	0.02
	AC1	-0.03	-0.01	0.15	0.02	-0.07	0.90	-0.06	0.04

	AC1	0.35	0.00	-0.03	0.06	-0.05	0.62	0.02	-0.15
Emotional Connection	C1	0.02	0.11	0.01	0.03	0.55	0.10	0.07	-0.03
	C2	0.15	0.20	-0.23	-0.02	0.58	-0.09	0.08	0.02
	S1	0.55	-0.06	0.07	0.09	0.20	0.09	-0.09	-0.01
	S4	-0.03	0.18	-0.06	-0.09	0.71	-0.07	0.15	-0.12
	S5	0.62	0.03	0.07	-0.15	0.22	0.03	0.02	0.01
	S6	0.70	0.18	-0.09	-0.17	0.17	0.09	0.08	-0.13

Note. Instruction-related factors: SR = Close Social-emotional Relationship; E = Sense of Ease; EF = Senses of Self and Collective Efficacy; A = Adaptation to Group Regulation; CE = Efforts for Group Consensus; L = Sense of Leadership to Group Learning; DB = Benefitting from Diverse Resources; HB = Benefitting from Homogeneous Value; AC = Achievability from Contribution to Group Success; C = Cognitive Awareness; S = Social Awareness

Second, I further modified the rest 46 items according to rationality of the item coherence. In the two-level measurement model, each perceptual construct was associated with several instruction-related factors. Thus, in observations, it would be predictable that items falling in a same construct loaded on a same factor though they were theoretically designed for different factors within the construct. For example, in the *Perception of Influence* construct, the item *A1*, *A2*, *CE4*, and *CE5* loaded on *F5*. These items were all designed to assess the *Perception of Influence* construct. The *Adaptation to Group Regulation (A)* factor and *Efforts for Group Consensus (CE)* factor were the two instruction-related factors leading to perception of influence. Therefore, these items might share a common variance (i.e., loaded on a same factor as shown). Conversely, if the items falling into different perceptual constructs loaded on a same factor, it would indicate that these items shared a common variance. However, these items were designed to assess different perceptual constructs, so they should not share a common variance. For example, the items, *C1, C2, S4, A1*, *A2, CE4,* and *CE5* loaded on *F5*. *C1, C2,* and *S4* were designed to assess the *Emotional Connection* construct and *A1, A2, CE4,* and *CE5* assessed the *Perception of Influence* construct. These items' sharing a common variance could not be supported by the proposed measurement model. The

other violating items were *EF1* - *EF6* and *L1 – L3* unexpectedly loading on *F2.* In addition, *S1, S5, S6* and *AC4 – AC9* also unexpectedly loaded on *F1* (see Table 5). These discrepancies needed to be fixed, for which two methods were considered. One was to keep the items that unexpectedly loaded on a same factor and revise the measurement model based on the item coherence. The other was to delete the items to further shorten the second instrument version. In this pilot study, I give priority to the second solution.

For the violating items in the *Emotional Connection* construct (i.e., *C1, C2, S1, S4 – S6*), the *Fulfillment of Needs* construct (i.e., *AC4 – AC9*), the *Perception of Influence* construct (i.e., *A1, A2, CE4, CE5*), I deleted the violating items in the *Emotional Connection* construct except for the item *S1*. The *EFA* output showed that deletion of this kind matched the item coherence with the proposed factorial structure better, compared with deleting *AC4 – AC9* or deleting *A1, A2, CE4,* and *CE5* (see Table 6). In addition, for the violating items in the *Feeling of Membership* construct (i.e., *EF1 – EF6*) and *Fulfillment of Needs* construct (i.e., *L1 – L3*), I did not delete any item. *EF1 – EF6* were designed for the *Senses of Self and Collective Efficacy* factor and *L1 – L3* for the *Sense of Leadership to Group Learning* factor. Based on the literature review, learners with strong senses of self and collective efficacy can perceive strong individual and group capabilities and thus are more likely to be confident with their leadership on team work in face-to-face learning communities (Oliver & Hipp, 2006). Hence, it could be predictable for these items to share a common variance. Keeping these items could investigate the relationship between senses of self- and collective efficacy and

leadership in online learning communities. In short, the further modification lead to the third instruction version (the 41-item version).

I submitted the third instrument data to *EFA-ML,* fixing the number of the factors as eight and allowing them correlated with the Promax rotation again. The *EFA* output suggested the necessity of deleting the items in the *Perception of Influence* construct (i.e., *A1, A2, CE4, CE5*). The *EFA* output indicated that the item *A1*did not saliently load on any factors, and the item *A2* and the item *E4 - E6* in the *Feeling of Membership* construct loaded on a same factor (see Table 7). Thus, based on the first and second criterion of the instrument modification, *A1* and *A2* were deleted. After that, only *CE4* and *CE5* were left to assess the *Perception of Influence* construct. According to the third criterion of the instrument modification that only factors having three or more than three salient items can be kept assuring a statistically meaningful estimation of latent factor scores (Hindman et al., 2016), the item *CE4* and *CE5* were deleted. The further item deletion lead to the fourth instrument version (37-item version).

Table 7

Factor Loadings for the Third Instrument Version (41 items)

Constructs		Factors							
	Items	F1	F2	F3	F4	F5	F6	F7	F8
Feeling of Membership	SR1	-0.02	-0.04	0.01	0.78	0.10	0.03	0.10	-0.21
	SR3	-0.07	0.06	0.06	0.67	0.15	-0.06	0.17	-0.17
	E1	-0.01	0.14	-0.06	0.19	0.03	-0.02	0.71	-0.12
	E2	0.10	0.03	0.16	0.21	-0.04	-0.02	0.55	0.09
	E3	0.01	0.20	0.08	-0.01	-0.04	0.09	0.79	-0.13
	E4	0.06	-0.15	-0.06	0.84	-0.03	-0.07	0.06	0.31
	E5	-0.02	-0.09	-0.01	0.91	-0.01	-0.02	0.02	0.15
	E6	0.06	0.04	-0.02	0.62	-0.09	0.02	0.01	0.23
	EF1	-0.09	0.66	-0.24	-0.13	-0.02	0.18	0.20	0.15
	EF2	-0.06	0.66	-0.22	-0.18	0.01	0.08	0.19	0.13
	EF3	0.19	0.53	0.01	0.01	0.01	0.11	0.03	-0.05
	EF4	0.10	0.92	0.01	0.09	-0.05	-0.09	-0.04	-0.05
	EF5	-0.06	0.88	0.13	0.18	-0.05	-0.10	-0.05	-0.08

	EF6	-0.17	0.57	-0.04	0.26	0.00	0.19	-0.12	0.06
Perception of Influence	A1	-0.02	0.34	0.02	0.23	0.03	0.04	-0.05	0.32
	A2	0.08	0.26	-0.12	0.44	-0.07	0.10	-0.18	0.31
	CE4	0.07	0.08	-0.05	0.10	-0.02	0.00	-0.06	0.44
	CE5	0.08	0.10	0.26	0.04	0.07	0.01	-0.11	0.40
Fulfillment of Needs	L1	-0.02	0.66	0.13	-0.07	-0.02	-0.05	-0.02	0.09
	L2	0.16	0.54	0.00	-0.08	0.03	-0.02	0.06	0.07
	L3	0.02	0.47	0.36	-0.18	0.07	-0.07	0.05	0.01
	DB	0.03	0.18	0.59	-0.02	0.02	-0.04	0.03	0.18
	DB	-0.02	0.15	0.62	-0.01	0.11	-0.01	-0.01	0.24
	DB	-0.10	-0.11	0.79	-0.03	-0.01	0.09	0.05	0.29
	DB	0.06	-0.05	0.77	-0.06	-0.03	0.01	-0.05	0.15
	DB	0.10	-0.16	0.72	0.05	-0.07	0.09	-0.01	0.20
	HB	0.07	0.01	-0.06	0.02	0.02	0.70	0.09	0.13
	HB	-0.02	0.06	0.10	-0.06	0.08	0.81	0.03	-0.03
	HB	0.06	0.11	0.24	0.02	-0.01	0.65	-0.05	-0.10
	AC	-0.05	-0.10	0.78	0.01	-0.03	0.04	0.01	-0.23
	AC	0.03	0.09	0.82	0.04	0.01	-0.02	0.06	-0.27
	AC	0.64	-0.02	0.04	0.17	-0.03	0.03	0.10	0.14
	AC	1.01	0.02	-0.24	-0.11	0.12	-0.07	0.06	0.21
	AC	0.90	0.10	-0.05	-0.09	0.00	-0.06	0.06	0.10
	AC	0.95	0.10	0.11	-0.04	-0.11	-0.02	0.02	-0.12
	AC	0.95	-0.04	0.10	0.04	-0.03	0.06	-0.06	-0.20
	AC	0.67	-0.23	0.04	0.07	-0.05	0.28	-0.08	-0.02
	AC	-0.08	-0.04	-0.13	0.09	0.86	0.14	0.01	-0.02
	AC	-0.04	-0.01	0.13	-0.03	0.90	-0.07	0.05	0.03
	AC	0.33	0.02	-0.01	0.03	0.63	0.03	-0.16	-0.04
	S1	0.54	-0.02	0.05	0.12	0.09	-0.07	-0.03	0.20

Note. Instruction-related factors: SR = Close Social-emotional Relationship; E = Sense of Ease; EF = Senses of Self and Collective Efficacy; A = Adaptation to Group Regulation; CE = Efforts for Group Consensus; L = Sense of Leadership to Group Learning; DB = Benefitting from Diverse Resources; HB = Benefitting from Homogeneous Value; AC = Achievability from Contribution to Group Success; C = Cognitive Awareness; S = Social Awareness

After the deletions mentioned above, *EFA-ML* with fixed eight factors and Promax rotation was conducted again. The *EFA* output indicated that there was no item violating any instrument modification criteria and the observed item coherence was similar with the proposed factorial structure (see Table 8). I renamed the factors to better reflect the content of the item coherence (see Table 9). In short, the proposed measurement model was refined, but the perceptual and the instruction-related levels

were retained. In the fourth instrument version, 37 items were left to assess the remaining two perceptual constructs and seven instruction-related factors (see Table 9).

Table 8

Factor Loadings for the Fourth SoC in CSCL *Instrument Version (37 items)*

Constructs	Items	Factors						
		F1	F2	F3	F4	F5	F6	F7
Feeling of Membership	SR	-0.05	0.10	-0.10	0.63	0.11	0.02	0.10
	SR	-0.11	0.18	-0.03	0.55	0.16	-0.07	0.16
	E1	-0.02	0.12	-0.08	0.12	0.03	-0.03	0.75
	E2	0.11	-0.01	0.18	0.23	-0.04	-0.01	0.56
	E3	0.00	0.15	0.06	-0.08	-0.04	0.07	0.83
	E4	0.09	-0.13	0.01	0.96	-0.04	-0.05	0.01
	E5	-0.02	-0.01	-0.01	0.95	-0.01	0.00	-0.02
	E6	0.08	0.07	0.03	0.72	-0.10	0.04	-0.05
	EF	-0.07	0.58	-0.16	-0.03	-0.04	0.20	0.17
	EF	-0.03	0.57	-0.16	-0.08	0.00	0.10	0.16
	EF	0.19	0.55	-0.01	0.00	0.01	0.11	0.01
	EF	0.09	0.96	-0.03	0.06	-0.05	-0.09	-0.06
	EF	-0.07	0.94	0.08	0.14	-0.05	-0.10	-0.06
	EF	-0.17	0.60	-0.04	0.29	-0.01	0.21	-0.16
	L1	0.01	0.63	0.16	-0.05	-0.02	-0.03	-0.02
	L2	0.17	0.50	0.04	-0.06	0.03	-0.01	0.06
	L3	0.02	0.44	0.40	-0.19	0.07	-0.07	0.07
Fulfillment of Needs	DB	0.04	0.16	0.66	0.03	0.02	-0.03	0.02
	DB	0.00	0.12	0.71	0.07	0.11	0.01	-0.03
	DB	-0.07	-0.14	0.91	0.07	-0.02	0.10	0.03
	DB	0.06	-0.07	0.86	-0.02	-0.03	0.00	-0.06
	DB	0.10	-0.17	0.83	0.11	-0.08	0.09	-0.04
	HB	0.09	-0.01	-0.01	0.09	0.01	0.71	0.06
	HB	-0.02	0.08	0.09	-0.08	0.08	0.81	0.02
	HB	0.05	0.17	0.19	-0.03	0.00	0.63	-0.05
	AC	-0.09	0.00	0.66	-0.12	-0.01	0.02	0.03
	AC	-0.01	0.20	0.67	-0.09	0.03	-0.04	0.07
	AC	0.67	-0.02	0.07	0.23	-0.04	0.03	0.07
	AC	1.03	-0.05	-0.15	-0.02	0.11	-0.05	0.04
	AC	0.93	0.07	-0.02	-0.05	-0.01	-0.06	0.04
	AC	0.93	0.14	0.03	-0.10	-0.09	-0.03	0.03
	AC	0.91	0.05	0.01	-0.06	-0.02	0.04	-0.04
	AC	0.69	-0.18	0.00	0.04	-0.05	0.27	-0.07
	AC	-0.08	-0.06	-0.12	0.05	0.87	0.13	0.03
	AC	-0.03	-0.04	0.16	-0.03	0.89	-0.07	0.05
	AC	0.33	0.04	-0.03	0.00	0.64	0.02	-0.16
	S1	0.58	-0.04	0.10	0.19	0.08	-0.05	-0.06

Note. Instruction-related factors: SR = Close Social-emotional Relationship; E = Sense of Ease; EF = Senses of Self and Collective Efficacy; L = Sense of Leadership to Group Learning; DB = Benefitting from Diverse Resources; HB = Benefitting from Homogeneous Value; AC = Achievability from Contribution to Group Success; S = Social Awareness

Table 9

The Fourth SoC in CSCL *Instrument Version*

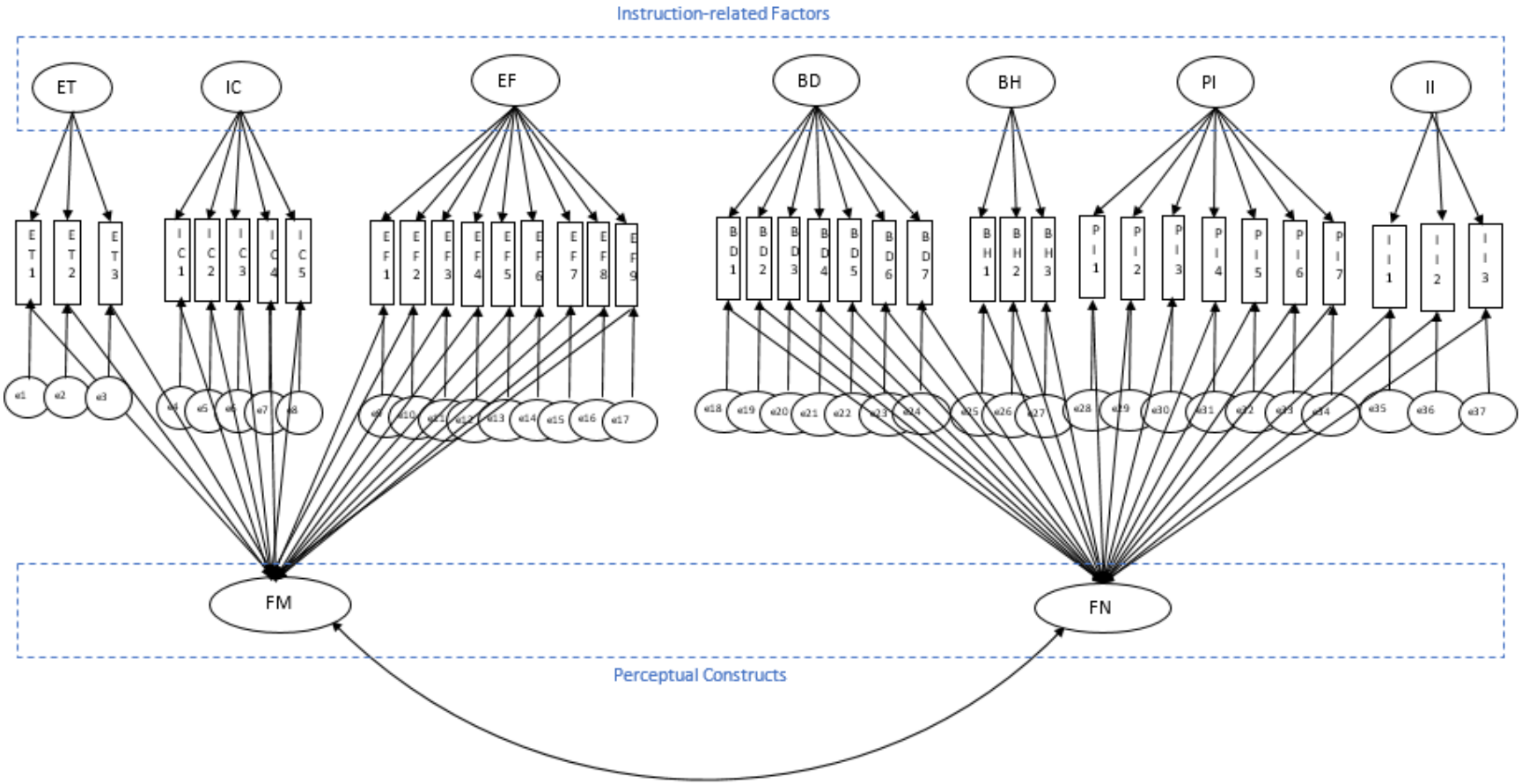
Perceptual Constructs	**N of Items**	**Instruction-Related Factors**	**N of Items**
Feeling of Membership	17	Ease of Using Techniques	3
		Close Interpersonal Connection	5
		Senses of Self- and Collective Efficacy	9
Fulfillment of Needs	20	Benefitting from Diverse Resources	7
		Benefitting from Homogeneous Value	3
		Active Peer Interaction	7
		Active Interaction with Instructors	3
Total	37		37

CFA. Given the fourth instrument version (the 37-item version), I submitted the data to *CFA*, using bi-factor modeling in SAS again. Specifically, the 37 instrument items were allowed to equally load on their corresponding factors and constructs. The two constructs were allowed to correlate with each other; but there was no correlations among the seven factors (see Figure 2) because the seven factors here were seen as the independent factors that accounted for additional variances of the items (Reise, 2012).

Three fit indices (i.e., *RMSEA*, *CFI*, and *TLI*) in the *CFA* output were examined to confirm the goodness of fit between the observed data interpretation and the initially revised measurement model. As to the cutoff values of the three fit indices that indicate goodness of model fit, *RMSEA* value below .08 indicates an acceptable fit and at or

near .05 indicates excellent fit (MacCallum, Browne, & Sugawara 1996; Steiger & Lind, 1980); *CFI* value greater than or equal to .90 indicates good fit (Bentler, 1990); *TLI* value greater than or equal to .90 indicates good fit (Tucker & Lewis, 1973). If the three indices reached the acceptable standards at the same time, I would claim that the initially revised measurement model reproduced the observed instrument data. Otherwise, I would further modify the *SoC in CSCL* instrument towards a better version.

Figure 2. The Refined Measurement Model Underlying the Fourth *SoC in CSCL* Instrument Version



Note. Instruction-related factors: ET = Ease of Using Techniques; IC = Close Interpersonal Connection; EF = Senses of Self- and Collective Efficacy; BD = Benefitting from Diverse Resources; BH = Benefitting from Homogeneous Value; PI = Active Peer Interaction; II = Active Interaction with Instructors; Perceptual constructs: FM = Feeling of Membership; FN = Fulfillment of Needs

According to the *CFA* output, First, I checked whether doublet factors occurred (Hennessey, Terry, Martin, McConnell, & Willis, 2017). Doublet factors refers to pairs of items loading on same factors but having unexplainable residual variances (Landis, Edwards, & Cortina, 2011), which would impact the fit of a measurement model. Landis and his colleagues (2011) proposed two solutions to the problem. The first solution was to correlate the residuals that should have been statistically independent. However, this solution would make the measurement model more complex to explain. The second solution was to delete one item from a doublet pair to keep the simplicity of the measurement model and shorten the instrument. In this pilot study, if there were four or more items included in the factor where the doublet factor occurs, I would follow the second solution; otherwise I would do the first one, because I have to keep the factors having three or more salient items to assure a statistically meaningful estimation of latent factor scores (Hindman et al., 2016). After each step mentioned above, I re-submitted the further modified instrument data to *CFA* until a statistically acceptable measurement model was generated. Second, I modified the items that neither loaded on their associated factor nor construct. If a factor that needed to be modified only had three items or less, the item(s) that did not have salient factor loading(s) would be replaced by new one(s). Otherwise, I would delete the items to shorten the second instrument version.

Results. As a result, the fit statistics for this bi-factor measurement model were less than acceptable level (χ^2 = 1596.436, *df* = 592; *RMSEA* = .091, *CFI* = .852, *TLI* = .834), so the fourth instrument version needed further modification. The *CFA* output indicated that doublet pairs occurred in *Close Interpersonal Connection* factor, *Senses*

of Self- and Collective Efficacy factor, *Benefitting from Diverse Resources* factor, and *Active Peer Interaction* factor. Hence, I deleted one item from each doublet pair sequentially from the pair with the largest residual variance through the smallest one. For example, the items *BD6* and *BD7* shared largest unexplainable residual variances, so I started the deletion from this doublet pair. The item *BD7* also shared large residual variances with the other items. Hence, I decided to delete the item *BD7* and kept the item *BD6*. After dealing with each doublet pair, I re-submitted the revised instrument data to *CFA* until no more doublet pairs were found. Using this procedure, 13 items were deleted from the fourth instrument version, and the last *CFA* output indicated an acceptable fit of the construct structure (χ^2 = 409.386, *df* = 209; *RMSEA* = .068, *CFI* = .945, *TLI* = .927).

In addition, most factor loadings were significant and R^2 value for most of the items loading on the two constructs (*FM* and *FN*) were strong (see Table 10). However, the items, *II1-II3*, neither significantly load on their associated perceptual construct nor instruction-related factors. I temporarily kept them in the instrument because these items were designed to assess online learners' interaction with their instructors, which is the primary event leading to sense of community in CSCL environments (Weinberger et al., 2005; Weinberger & Fischer, 2006). In short, after further deleting items based on CFA output, the fifth instrument version was generated (24-item version).

Table 10

Factor Loadings and R2 *Values for the Bi-Factor Model Underlying the Fifth Instrument Version*

	ET		**IC**		**EF**		**BD**		**BH**		**PI**		**II**		**FM**		**FN**	
	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2
Item1	.58**	.34													.56**	.31		
Item2	.41**	.17													.70**	.49		
Item3	.80**	.64													.57**	.32		
Item4			.10	.01											.84**	.71		
Item5			.25**	.06											.79**	.62		
Item6			.34**	.12											.76**	.58		
Item7			.61**	.37											.79**	.62		
Item8					.63**	.40									.62**	.38		
Item9					.34**	.12									.60**	.36		
Item10					.60**	.36									.43**	.18		
Item11							.15	.02									.84**	.71
Item12							.08	.01									.85**	.72
Item13							.36**	.13									.75**	.56
Item14							.51**	.26									.86**	.74
Item15									.58**	.34							.59**	.35
Item16									.63**	.40							.60**	.36
Item17									.48**	.23							.69**	.48
Item18											.55**	.30					.74**	.55
Item19											.61**	.37					.64**	.41
Item20											.48**	.23					.52**	.27
Item21											.43**	.18					.60**	.36
Item22													.80	.64			.41	.17
Item23													.80	.64			.54	.29
Item24													.60	.36			.53	.28

Note. Instruction-related factors: ET = Ease of Using Techniques; IC = Close Interpersonal Connection; EF = Senses of Self- and Collective Efficacy; BD = Benefitting from Diverse Resources; BH = Benefitting from Homogeneous Value; PI = Active Peer Interaction; II = Active Interaction with Instructors; Perceptual constructs: FM = Feeling of Membership; FN = Fulfillment of Needs
**: p <.001

Reliability

Procedure. Cronbach's Alpha (α) and Omega (ω) coefficients were calculated to indicate the internal consistency of the whole instrument, its underlying perceptual constructs and instruction-related factors. Cronbach's Alpha is an important reliability evidence, for which .80 is considered as an acceptable coefficient for ability or aptitude tests (DeVellis, 2016). If Cronbach's Alpha is greater than .80, it means scores from the tested items are reliable in that sample. However, Cronbach's Alpha has fundamental problem. That is, the reliability coefficient "implies nothing about the stability of the test scores over time or their equivalence to scores on one particular alternate form of the test" and thus is usually seen as the lower bound to reliability (Crocker & Algina, 1986, p. 142). In this pilot study, Omega was additionally utilized to assess the internal consistency, which can solve the fundamental problem of Cronbach's Alpha (Peters, 2014). Compared to Cronbach's Alpha, Omega takes account of the correlation between items and constructs as well as item-specific measurement errors. Therefore, Omega provides a better estimate of reliability for an instrument. In this pilot study, the cutoff value for Omega was .80, and the interpretation of this coefficient was same as for Cronbach's Alpha.

Results. The reliability analysis result indicated that the overall instrument exhibited adequate reliability, α = .944 and ω = .957. For the two perceptual constructs, the reliability estimates were also high, α = .902 and .924 and ω = .948 and .961. For the seven instruction-related factors, the Cronbach's Alpha coefficients and Omega coefficients were also good enough, except for the *Senses of Self- and Collective*

Efficacy factor with the Cronbach's Alpha value a little lower than the cutoff value, α = .791 (see Table 11).

Table 11

Reliability of the Fifth SoC in CSCL *Instrument Version*

Perceptual Constructs	**Instruction-Related Factors**	**Item N**	**Mean**	***α***	***ω***
Feeling of Membership (FM)		10	6.575	.902	.948
	• Ease of Using Techniques (*ET*)	3	6.827	.882	.900
	• Close Interpersonal Connection (*IC*)	4	6.416	.844	.929
	• Senses of Self- and Collective Efficacy (*EF*)	3	6.536	.791	.810
Fulfillment of Needs (FN)		14	6.431	.924	.961
	• Benefitting from Diverse Resources (*BD*)	4	6.430	.905	.934
	• Benefitting from Homogeneous Value (*BH*)	3	5.984	.879	.882
	• Active Peer Interaction (*PI*)	4	6.130	.884	.889
	• Active Interaction with Instructors (*II*)	3	7.280	.843	.885

Conclusion

The fifth instrument version (the 24-item version) was generated and its underlying bi-factor measurement model were confirmed via combination of *EFA* and *CFA*. Reliability analysis also exhibited adequate internal consistency of the whole instrument, its underlying perceptual constructs and instruction-related factors.

Measurement model of an well-developed instrument should be replicated across different samples and times to maintain scientific integrity, so that the observed performance in a test can be generalized to a universe of expected performance which the test aims at measuring (Burman, Reed, & Alm, 2010; Kane, 2016). Hence, the measurement model fit confirmed in the pilot study should be investigated in another data collection and analysis. If the model fit was replicated in a new sample, we would confidently claim that the *SoC in CSCL* instrument measured that it aimed at measuring.

Chapter 4: Replication Study: Methodology

General Study Procedure

In Chapter 2 and 3, I proposed a theoretical framework for the concept of Sense of Community in Computer-Supported Collaborative Learning via conducting a comprehensive literature review. I used the theoretical framework as a measurement model to develop a new instrument named as *SoC in CSCL* and validated the measurement model using statistical evidence. The bi-factor measurement model was refined, and the instrument modification went through five versions. The bi-factor measurement model contained instruction-related level and perceptual level. The perceptual level included two constructs: *Feeling of Membership* and *Fulfillment of Needs*. The instruction-related level included seven factors: *Ease of Using Techniques, Close Interpersonal Connection*, *Sense of Efficacy*, *Benefitting from Diverse Resources, Benefitting from Homogeneous Value, Active Peer Interaction*, and *Active Interaction with Instructors* (see Figure 4). The seven instructional factors were seen as the independent factors that accounted for additional variances in the items (Reise, 2012). In the final version of the instrument, 24 Likert-type items were kept representing the bi-factor measurement model.

Chapter 4 and 5 will conduct a replication study to provide generalizability evidence, reliability estimates, and external evidence for further validating the measurement model underlying the instrument. Specifically, the third and fourth research questions will be answered:

- Can the refined measurement model be replicated in a new sample?

- How is the refined measurement model underlying the modified *SoC in CSCL* instrument explained by observed data?
- Are scores obtained from the modified *SoC in CSCL* instrument reliable?

- Are online learners' scores on the two criterion instruments, *Self-Efficacy Instrument* (*SEI*) and *Intrinsic Value Instrument* (*IVI*), highly correlated with their scores on the modified *SoC in CSCL* instrument?

Chapter 4 will describe the procedures needed to answer the research questions above. First, I will distribute the fifth instrument version (see Appendix B) to undergraduate and graduate students taking online courses at the same major university in the spring and summer semesters of 2017. I will submit then students' instrument data to Confirmatory Factor Analysis (CFA) to confirm the fit between the new observed data and the refined measurement model. In addition, Cronbach alpha (α) and Omega (ω) coefficients will be calculated to assess the internal consistency of the modified instrument and its underlying perceptual constructs and instruction-related factors. The correlations between the fifth instrument version, its underlying constructs and factors, and two criterion instruments were computed to provide the external evidence for validating the modified instrument.

The Fifth SoC in CSCL Instrument Version

The *SoC in CSCL* instrument was revised five times sequentially according to the EFA and CFA outputs in the pilot study. The measurement model underlying the fifth instrument version consisted of two perceptual constructs: *Feeling of Membership* and *Fulfillment of Needs*. The first construct was related to three instruction-related factors: *Ease of Using Techniques* (*ET*, represented by 3 Likert-type items*), Close*

Interpersonal Connection (*IC*, represented by 4 Likert-type items), and *Sense of Efficacy* (*EF*, represented by 3 Likert-type items). And the second perceptual construct was associated with four instruction-related factors: *Benefitting from Diverse Resources* (*BD*, represented by 4 Likert-type items), *Benefitting from Homogeneous Value* (BH, represented by 3 Likert-type items), *Active Peer Interaction* (*PI*, represented by 4 Likert-type items), and *Active Interaction with Instructors* (*II*, represented by 3 Likert-type items) (see Table 9 and Appendix B). All items in the instrument were rated by an 8-point scale from 1 (*Strongly Disagree*) to 8 (*Strongly Agree*). Respondents indicated how much they agreed or disagreed with each item by clicking one of the eight points that corresponds with their current online learning experience.

Criterion Instruments

To provide the external evidence for the *SoC in CSCL* instrument development, criterion instruments are needed to test their correlations with the interested instrument. Sense of community in CSCL had been demonstrated correlated with learners' self-efficacy and intrinsic value on CSCL (Wang & Newlin, 2002; Wang & Hwang, 2012; Wang & Lin, 2007). The *Motivated Strategies for Learning Questionnaire (MSLQ)* was developed based on a social-cognitive perspective of self-regulated learning to measure the types of learning strategies and academic motivation. This questionnaire consists of five components: self-efficacy, intrinsic value, text anxiety, cognitive strategy use, and self-regulation (Pintrich, 2003). Hence, I borrowed the components about self-efficacy and intrinsic value from the *MSLQ* and adapted them to CSCL environments for using it as the criterion instruments in the replication study (see Appendix B).

Intrinsic Value Instrument (IVI) assessed how the online learners intrinsically valued the online collaborative learning. Six Likert-type items were borrowed from the *MSLQ* and the statements of the items were tailored to CSCL environments. For example, one original item was stated as “I think I will be able to use what I learn in this class in other classes”. I revised the statement into “I will be able to use what I learn in this online course in other courses” to show the characteristics of online learning. The *IVI* is rated using a seven-point scale anchored with 1 (*not at all true of me*) to 7 (*very true of me*). In the replication study, Cronbach’s Alpha was computed first to indicate the internal consistency of the criterion instrument. The result showed adequate reliability for the instrument, $\alpha = .934$.

Self-Efficacy Instrument (SEI) assessed online learners’ belief in their capability to achieve online collaborative learning goals. Seven Likert-type items were borrowed from the *MSLQ*. Their statements were also revised to adapt to CSCL environments. For example, one original statement is “I’m confident I can learn the basic concepts taught in this course”, and it is revised into “I'm confident I can learn the basic concepts taught in this online course”. The *SEI* has the same rating with the *IVI*. In the replication study, Cronbach’s Alpha coefficient showed adequate internal consistency for this criterion instrument, $\alpha = .954$.

Data Collection

Recruitment

After obtaining IRB approval (see Appendix C), I identified the instructors who were teaching online courses at a Midwestern university of the United States via the course enrollment website of this university. This website provides a function "Look up

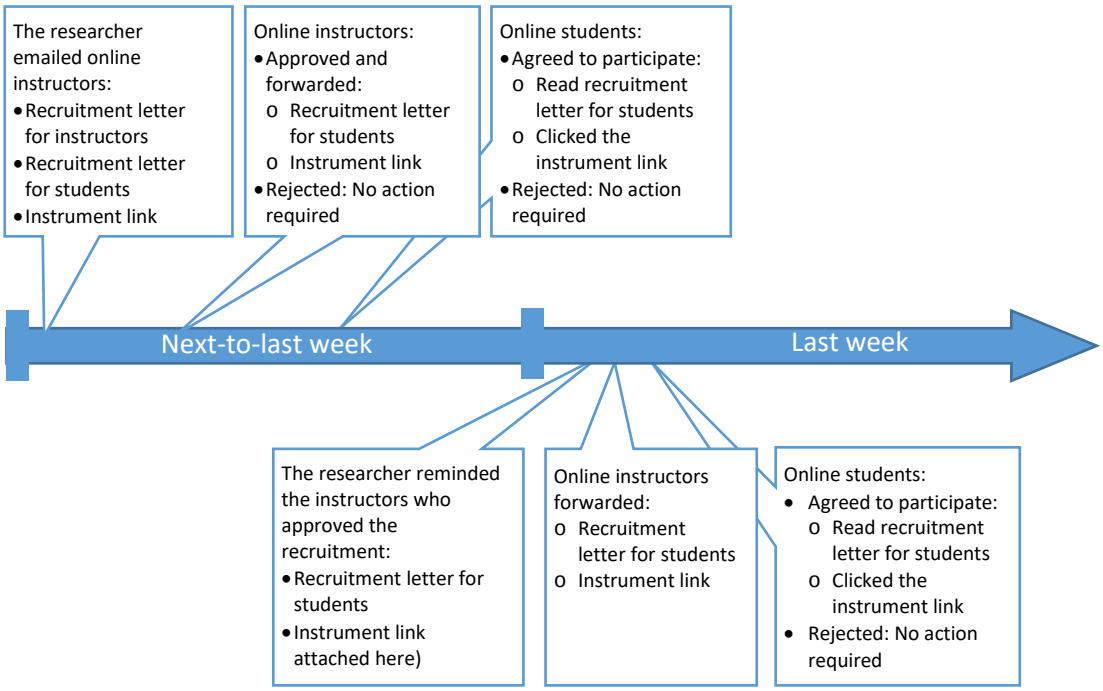
Classes" for students and faculty to search and enroll courses. I took use of this function to search online courses and extracted information about meeting time of online course and instructors' email addresses.

Like the procedures in the pilot study, I targeted the courses that involved online synchronous or asynchronous interaction. Interaction in online learning environments can be divided into learner-learner communication, learner-instructor, learner-content, learner-interface, in pairs or groups, and with or without instructors (Hillman, Willis, & Gunawardena, 1994; Moore, 1989). In this present study, sense of community is defined as a psychological consequence of individual learning experience in CSCL environments (Blanchard & Markus, 2004; Brook & Oliver, 2002). The primary learning experience in CSCL are online learners' synchronously or asynchronously interaction for sharing and constructing knowledge (Weinberger, Ertl, Fischer, & Mandl, 2005; Weinberger & Fischer, 2006). Therefore, this study targeted the online courses that involved peer interactions, but was not limited to this interaction. To do that, in the recruitment email for the online instructors (see Appendix D), I emphasized that "if your online course(s) involve(s) online discussion or collaborative group work, please forward the following recruitment email to the students who enrolled your online course(s) and inform me of that action."

As in the pilot study, I contacted the online instructors of the targeted online courses by email to ask for approval to recruit from their online students. After approving the recruitment, the online instructors were asked to forward another recruitment email to their online students, where the online instrument link was attached (see Appendix E). The students who were willing to participate in this study clicked the

attached link in the recruitment email to access the online instrument (see Figure 3). In the first webpage of the online instrument, students read the consent form to obtain detailed information about this study. After reading the consent form, the students decided whether to participate in this research via clicking "I agree to participate" or "I do not want to participate" at the end of the consent form webpage (see Appendix F).

Figure 3. The Procedure for Recruiting Online Students for the Replication Study



Fourth, to encourage more participation in this study, I contacted one instructional designer, who designs online courses for some colleges at the university and has connections with some online instructors and professors. This instructional designer forwarded the recruitment letter to the online instructors. In addition, the Dean of one college at the university having degree program completely online helped me contact instructors from their college to recruit students.

Instrument Administration

The fifth *SoC in CSCL* instrument version (see Appendix B) was distributed through Qualtrics.com, an online password protected survey management website. Hence, there was no limitation on location and time for the student participants to response to the instrument. The online instrument was distributed in the next-to-last week of the targeted online courses, because the students of the online courses were expected to have enough opportunities to interact and collaborate with one another. One reminder was send to instructors, the instructional designer, and the Dean in the last week of the targeted online courses to increase the sample size.

Each participant independently responded to the instrument. While answering the instrument, the participants could suspend answering it and accessed it again to complete the rest questions whenever they were available. The participants could go back to previous questions to change their responses via clicking the "Back Button" at the bottom of each page of the online instrument. However, the participants could not change their responses once they clicked the button "<<" at the bottom of the last page of the online instrument.

Demographic questions were asked first, including participants' gender, age, ethnicity, enrollment status, and current registration status (see Appendix B). Then, the participants were routed to the fifth *SoC in CSCL* instrument version, the 24 Likert-type questions assessing their feeling of membership (10 questions) and fulfillment of needs (14 questions) in their online courses. The *Self-Efficacy Instrument* (*SEI*, 7 questions) and *Intrinsic Value Instrument* (*IVI*, 6 questions) followed (see Appendix B). At the last page of this online instrument, participants were encouraged to fill out their email addresses to enter a raffle for one of ten 50-dollar gift cards. Meanwhile, participants

were informed that the participation of the raffle drawing was voluntary, and if they refused to fill out their email addresses, they were still eligible to participate in the study via clicking the button "<<" at the bottom of the last webpage to submit their responses.

Data Analysis Plan

The data analysis plan in this chapter was designed to confirm whether the refined measurement model could be replicated in a new sample to provide generalizability evidence, reliability estimates, and external evidence. SAS was used to conduct the data analysis. I downloaded the original SPSS data file from Qualtrics.com for using it in SAS. I created new variables to input the mean scores of the fifth instrument version, its underlying perceptual constructs and instruction-related factors, and the two criterion instruments for the correlation analysis.

Descriptive Analysis

First, frequency analyses were conducted for the first six demographic questions (see Appendix B), which referred to online learners' gender, age, ethnicity, enrollment status, current registration status, and major. Second, frequencies were analyzed for the following question 7, 9, and 10 to investigate the situation of participants' previous and current online learning experience. Third, mean scores were computed for the question 8 and 11 to investigate the participants' degree of satisfaction to their previous learning experience and the time spent on online discussion or collaborative learning in their current online courses.

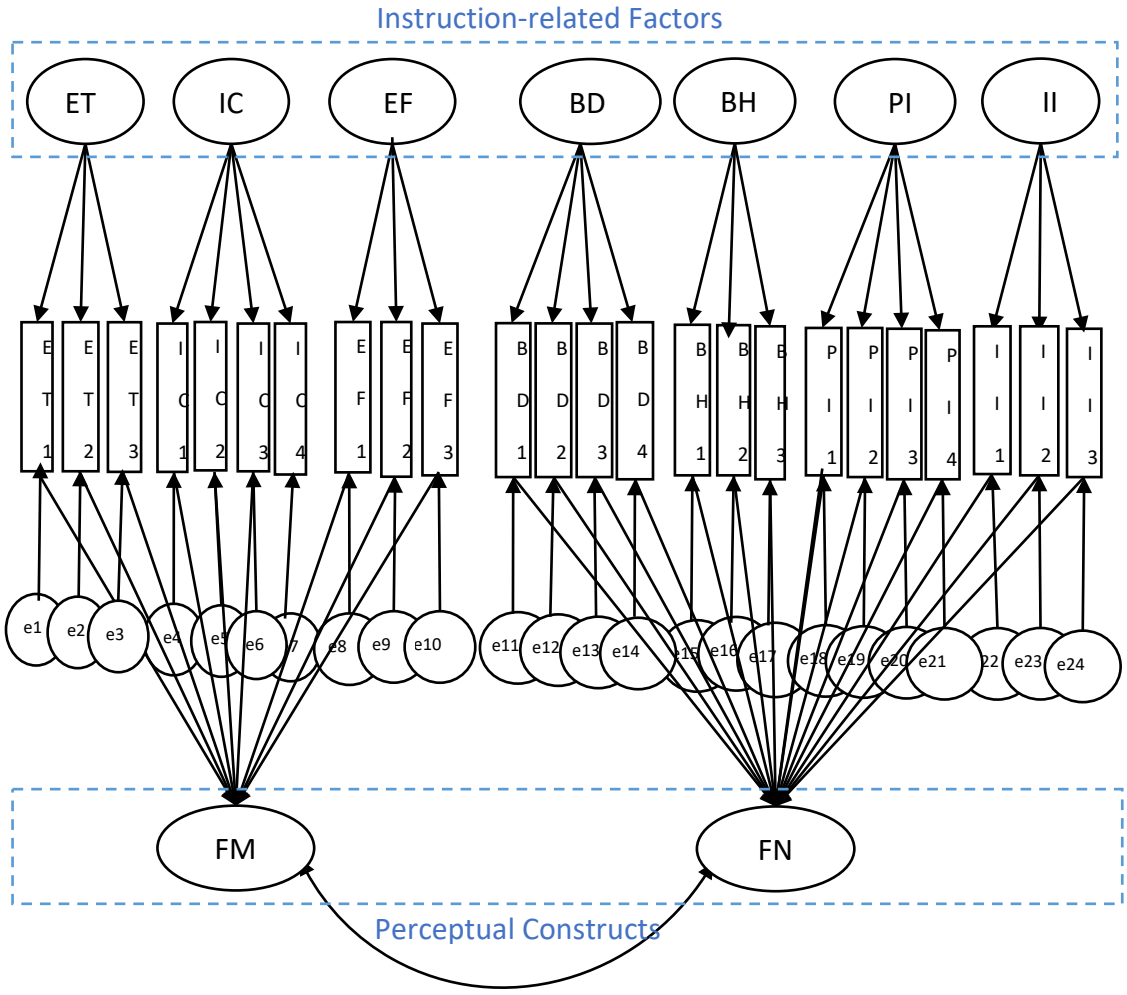
Generalizability Evidence

Generalizability evidence in measurement development is critical, which is to confirm whether the measurement model underlying a test is generalizable in the

targeted research field. Sampling conditions can influence data collection and analysis results. Hence, measurement developers have to demonstrate the scientific integrity of the analysis results (Burman et al., 2010) and thus ensure the test being conducted could be generalizable to individuals not in the present sample (American Educational Research Association et al., 2014).

SAS was used for data analysis in the replication study. I submitted the scores obtained from the fifth *SoC in CSCL* instrument version to *CFA* using bi-factor modeling (Figure 3) to determine the extent to which the model fit was appropriate in the new sample. The bi-factor measurement model underlying the fifth instrument version contained the instruction-related factors and perceptual constructs identified in the literature review and the pilot study. The perceptual level included two constructs: *Feeling of Membership* and *Fulfillment of Needs,* which were correlated with each other. The instruction-related level included seven factors: *Ease of Using Techniques, Close Interpersonal Connection, Sense of Efficacy, Benefitting from Diverse Resources, Benefitting from Homogeneous Value, Active Peer Interaction*, and *Active Interaction with Instructors* (see Figure 4). The seven instruction-related factors were set not correlated with one another, because they were seen as the independent factors that accounted for additional variances of the items (Reise, 2012).

Figure 4. The Measurement Model of the Fifth *SoC in CSCL* Instrument Version



Note. ET = Ease of Using Techniques; IC = Close Interpersonal Connection; EF = Sense of Efficacy; BD = Benefitting from Diverse Resources; BH = Benefitting from Homogeneous Value; PI = Active Peer Interaction; II = Active Interaction with Instructors; FM = Feeling of Membership; FN = Fulfillment of Needs

Three fit indices (i.e., *RMSEA*, *CFI*, and *TLI*) were extracted from the SAS output to evaluate whether the observed score interpretation in the fifth instrument version matched with the measurement model refined in Chapter 3 and whether the refined measurement model can be replicated in a new sample. The evaluation is based on the following criteria:

- *RMSEA* index below .08 indicates an acceptable fit and values at or near .05 indicate excellent fit (MacCallum, Browne, & Sugawara 1996; Sterger & Lind, 1980);
- *CFI* index greater than or equal to .90 indicates good fit (Bentler, 1990); and
- *TLI* Index greater than or equal to .90 indicates good fit (Tucker & Lewis, 1973).

If all of the three indices reached the acceptable level, the model fit would be confirmed, and the instrument results would be seen as generalizable on assessing online learners' sense of community in CSCL environments.

Reliability Analysis

Cronbach's Alpha (α) and Omega (ω) coefficients were respectively computed in SAS for the whole *SoC in CSCL* instrument and its underlying two perceptual constructs and seven instruction-related factors. The computations were to investigate the internal consistency of the instruments items. Most psychological scientists and educators for ability or aptitude tests consider .80 as an acceptable level of reliability (DeVellis, 2016). This cutoff value will be used to evaluate the extent to which scares from this sample can be considered as reliable. In addition, Omega was also computed to assess the internal consistency. Compared to Cronbach's Alpha, Omega considers the correlation between items and constructs as well as item-specific measurement errors. Therefore, Omega provides a better estimate of reliability for an instrument. The cutoff value for Omega in this replication study was also .80, and the interpretation of this coefficient was same as Cronbach's Alpha.

External Evidence

External evidence refers to the relationship between the interested test and criterion tests (i.e., whether the interested test shows correlation with related criterion tests). In the replication study, I evaluated the Pearson correlations between the mean scores obtained from the fifth *SoC in CSCL* instrument version, its underlying perceptual constructs and instruction-related factors, and the two criterion instruments, *Self-Efficacy Instrument* and *Intrinsic Value Instrument* to investigate the degree to which online learners' sense of community was related to their intrinsic value and self-efficacy for online collaborative learning. The correlation results would indicate the degree to which the instrument *SoC in CSCL* assessed the targeted perception.

Chapter 5: Replication Study: Results

Introduction

A bi-factor measurement model was statistically refined to conceptualize online learners' sense of community in CSCL environment. The *SoC in CSCL* instrument was accordingly modified through five versions. Chapter 4 and 5 aimed at replicating the refined measurement model to provide the validity evidence for the modified instrument. Methods presented in Chapter 4 specified the validation procedures, using the PROC CALIS package in SAS to replicate the refined measurement model in a new sample. Results presented in Chapter 5 will answer the following research questions:

- Can the statistically refined measurement model be replicated in a new sample?
  - How is the statistically refined measurement model underlying the modified *SoC in CSCL* instrument explained by observed data?
  - Are scores obtained from the modified *SoC in CSCL* instrument reliable?
- Are online learners' scores on the two criterion instruments, *Self-Efficacy Instrument (SEI)* and *Intrinsic Value Instrument (IVI),* highly correlated with their scores on the modified *SoC in CSCL* instrument?

Participants

In the replication study, the modified instrument (Appendix B) was distributed through Qualtrics.com and administrated to the students who were taking online courses in the spring and summer semesters of 2017 at a major university in the Midwestern section of the United States. In total, 801 online classes were scheduled in these two semesters, among which 52 online classes allowed me to recruit online students. The instructors of the 52 online classes were asked to forward a recruitment email to their

online students, where the instrument link was attached (Appendix E). In total, there were 192 online students willing to participate in this study and thus starting the online instrument. After the data collection, the data file was downloaded from Qualtrics.com for the follow-up data analysis. Data was submitted to CFA analysis using the PROC CALIS package in SAS to obtain the following results

In total, 192 online students participated in the replication study. Among the participants, there were 49 males, 141 females, 1 other, and 1 participant did not respond to the gender question. The group of 16-25 years old dominated the participants, accounting for around 58% of the sample with the majority of participants identified as white (see Table 12).

Table 12

Demographic Information for the Replication Study

	Replication Study		Pilot Study	
	Freq.	%	Freq.	%
Gender				
Male	49	25.5	45	21.8
Female	141	73.4	160	77.7
Other	1	.5	1	.5
Missing	1	.5	0	0
Age				
16-25	111	57.8	93	45.1
26-35	49	25.5	50	24.3
36-45	15	7.8	34	16.5
46-55	14	7.3	26	12.6
56-65	3	1.6	3	1.5
Missing	0	0	0	0
Ethnicity				
African American	10	5.2	10	4.9
Asian	16	8.3	15	7.3

Pacific Island	1	.5	0	0
Hispanic	12	6.3	5	2.4
Native American	13	6.3	13	6.3
White	136	70.8	154	74.8
Other	4	2.1	9	4.4
Missing	1	.5	0	0
Enrollment Status				
Full-time student	148	77.1	153	74.3
Part-time student	44	22.9	52	25.2
Missing	0	0	1	.5
Registration Status				
Degree seeking	188	97.9	203	98.5
Certificate seeking	2	1.0	1	.5
Non-degree seeking	1	.5	1	.5
Missing	1	.5	1	.5
Major				
Physical Science	4	2.1	3	1.5
Life Science	12	6.3	9	4.4
Engineering	14	7.3	11	5.3
Social Science	39	20.3	38	18.4
Humanities	13	6.8	16	7.8
Arts	18	9.4	26	12.6
Others	92	47.9	103	50.0
Missing	0	0	0	0

Participants in this replication study reported being enrolled in classes representing diverse major categories (see Table 12). 77.1% of participants were full-time students and 22.9% were part-time students (see Table 12). The majority of participants had experience in online courses; 85.9% of students reported previous experiences in online courses before taking the current class on which they reported with 37% of students taking more than four online classes previously. Overall, the students were satisfied with their current online courses (M = 6.40, N=164). 87.0% of

the courses set online discussion and collaboration as required. On average, each student reported spending 47.35% of class time on discussion and/or group work with 42.7% of students spent over half of their class participation in online discussion and collaboration.

Missing Data

192 participants responded to the instrument with approximately 16% of them (N = 31) not responding to all items. Of these 31, 10 skipped individual items and 21 ended participation before finishing all items. Incomplete observations were kept in the data file. First, the treatments of listwise deletion and pairwise deletion to the incomplete observations cause biased and/or inefficient estimates in data analysis (Rubin, 2004; Schafer, 1997). Second, deleting incomplete observations leads to the loss of information and thus decreases statistical power and increases standard errors (Peng, Harwell, Liou, Ehman, & others, 2006). Third, efficient missing data treatments are available to deal with the missing data, such as the multiple-imputation (*MI*) method, the full information maximum likelihood (*FIML*) method, and the expectation-maximization (*EM*) method, and so on, which generate better parameter estimates compared with listwise deletion and pairwise deletion (Dong & Peng, 2013).

Proportion

Proportion of missing data is associated with the quality of quantitative data analysis, but there is no cutoff to determine the validity of statistical reference (Dong & Peng, 2013). For instance, Bennet (2001) held that statistical estimates could be seen as unbiased when missing data is less than 10%. Enders (2003) stated that 15% to 20% missing data was common in the educational and psychological research.

PROC CALIS was used to analyze the proportion of missing data in the data file of the replication study, and the results showed that the missing data was minor (see Table 13) (Zhang & Yung, 2011). In Table 13, each entry indicated the proportion of the data available for calculating means or covariances of items, which is the base of structural equation modeling. The diagonal of the matrix table refers to the coverage of means. For example, the (1,1) entry showed that 99% participants responded to the item *ET1*, so 99% of observed data were available for calculating the mean value of this item. The off-diagonal of the matrix table showed the coverage of covariances that were calculated by the nonmissing item-pairs. For instance, the (1,2) entry, "97.4", indicated that 97.4% of the item-pairs of *ET1* and *ET2* were nonmisisng. In the data file of the replication study, the average proportion coverage of means and covariances were respectively 93.4% and 90.4%, which indicated that the missing data problem was not serious (Zhang & Yung, 2011). However, the proportion of missing data should not be the sole criterion for researchers to assess the quality of quantitative data analysis (Dong & Peng, 2013).

Patterns

Tabachnick and Fidell (2012) asserted that compared with the proportion, patterns of missing data have a greater effect on statistical inference. Theoretically, there are three missing data patterns: univariate, monotone, and arbitrary (Dong & Peng, 2013). The univariate pattern is found when more than one participant skips the same instrument item(s). The monotone pattern occurs when participants quit an instrument. The univariate pattern can also be monotone when participants quit at a same point in an instrument. The arbitrary pattern refers to skipping items in a random

fashion. In terms of the missing data patterns and associated descriptive analyses, I would deduce the mechanism of the missing data to decide the treatment for the missing data in the replication study. There are three mechanism of missing data: missing at random (MAR, missing data is depend on other observed variables), missing completely at random (MCAR, missing data is depend on observed or missing value), and missing not at random (MNAR, missing data is depend on missing value itself) (Enders, 2006).

PROC CALIS generated the top five missing data patterns as shown in Table 14, where "x" means participants' nonmissing entry in an item and "." means missing entry. For example, the first missing pattern in Table 14, "xxxxxxxxx……", showed participants responded to the first nine items and ended participation from the tenth item, and 29% of participants (N = 9) were observed to have the missing pattern. Table 14 showed that 51% of incomplete observations (N = 16) quitted the instrument, falling into the monotone pattern. 12% of incomplete observations (N = 4) skipped items, falling into the univariate pattern. The monotone and univariate patterns might indicate planned missingness.

Table 13

Proportions of Data Present for Means and Covariances for the Replication Study

	ET1	ET2	ET3	IC1	IC2	IC3	IC4	EF1	EF2	EF3	BD1	BD2	BD3	BD4	BH1	BH2	BH3	PI1	PI2	PI3	PI4	II1	II2	II3
ET1	.990																							
ET2	.974	.974																						
ET3	.984	.974	.984																					
IC1	.984	.969	.979	.990																				
IC2	.984	.969	.979	.990	.990																			
IC3	.984	.969	.979	.990	.990	.995																		
IC4	.990	.974	.984	.990	.990	.995	1.00																	
EF1	.979	.964	.974	.979	.979	.979	.984	.984																
EF2	.974	.958	.969	.974	.974	.974	.979	.979	.979															
EF3	.917	.901	.912	.922	.922	.922	.922	.922	.922	.922														
BD1	.917	.901	.912	.917	.917	.917	.922	.922	.922	.912	.922													
BD2	.917	.901	.912	.917	.917	.917	.922	.922	.922	.912	.922	.922												
BD3	.912	.896	.906	.912	.912	.912	.917	.917	.917	.912	.917	.917	.917											
BD4	.906	.891	.901	.906	.906	.906	.912	.912	.912	.906	.912	.912	.912	.912										
BH1	.906	.891	.901	.906	.906	.906	.912	.912	.912	.906	.912	.912	.912	.906	.912									
BH2	.906	.891	.901	.906	.906	.906	.912	.912	.912	.906	.912	.912	.912	.912	.906	.912								
BH3	.912	.896	.906	.912	.912	.912	.917	.917	.917	.906	.917	.917	.912	.912	.906	.912	.917							
PI1	.875	.859	.870	.880	.880	.880	.880	.880	.880	.880	.880	.880	.880	.875	.875	.875	.875	.880						
PI2	.875	.859	.870	.880	.880	.880	.880	.880	.880	.880	.880	.880	.880	.875	.875	.875	.875	.880	.880					
PI3	.875	.859	.870	.880	.880	.880	.880	.880	.880	.880	.880	.880	.880	.875	.875	.875	.875	.880	.880	.880				
PI4	.870	.854	.865	.870	.870	.870	.875	.875	.875	.870	.875	.875	.875	.870	.870	.870	.870	.870	.870	.870	.875			
II1	.885	.870	.880	.885	.885	.885	.891	.891	.891	.885	.891	.891	.891	.885	.885	.885	.885	.880	.880	.880	.875	.891		
II2	.885	.870	.880	.885	.885	.885	.891	.891	.891	.885	.891	.891	.891	.885	.885	.885	.885	.880	.880	.880	.875	.891	.891	
II3	.885	.870	.880	.885	.885	.885	.891	.891	.891	.885	.891	.891	.891	.885	.885	.885	.885	.880	.880	.880	.875	.891	.891	.891

Note: Instruction-related factors: ET = Ease of Using Techniques; IC = Close Interpersonal Connection; EF = Senses of Self- and Collective Efficacy; BD = Benefitting from Diverse Resources; BH = Benefitting from Homogeneous Value; PI = Active Peer Interaction; II = Active Interaction with Instructors

Table 14

The Five Most Frequent Missing Patterns for the Replication Study

	Pattern		Freq.	Proportion
1	xxxxxxxxx……	Monotone	9	29%
2	xxxxxxxxxxxxxxxxx…….	Monotone	5	16%
3	xxxxxxxxxxxxxxxxxxx.xxx	Univariate	2	6%
4	x.xxxxxxxxxxxxxxxxxxxxx	Univariate	2	6%
5	xxxxxxxxxx……...	Monotone	2	6%

Note. x = nonmissing response to an item; . = missing response to an item

Specifically, for the topmost monotone pattern in Table 14, nine participants quit at the tenth item, which stated, "I clearly know my role in online collaborative learning tasks" (see Appendix B). This item was designed to assess participants' experience on online collaborative learning. I extracted the nine participants' responses to one demographic question, "Did you participate in any online discussion or collaborative learning though they are not required in the class that you are taking?" (see Appendix B). It was found that only one of the nine participants responded "No" to this question, so it is predicable for this participant to intendedly quit at the tenth item. For the other eight participants, there was no descriptive evidence to indicate their planned missingness for the tenth item.

For the second monotone pattern in Table 14, five participants ended participation at the eighteenth item, which stated, "I enjoy the interaction with my classmates in the online course". This question was designed to assess participants' online peer interaction. I extracted their responses to another demographic question, "What percentage of the time did you spend on the online discussion or collaborative learning in the whole process of the online learning" and found only one participant

reported zero online interaction with the other classmates, so this participant's stoppage could be explained adequately. For the other four participants, no descriptive evidence can explain their stoppage.

For the least frequent monotone pattern in Table 14, two participants stopped participation at the eleventh item, "I benefit from the diverse experiences of my classmates in the online course". This question refers to online peer interaction and/or collaborative learning. However, no descriptive evidence was found to indicate that the two participants intentionally made no response to this question.

In addition, I checked the instrument structure and found that the questions where participants quit were either the first or the last question of a certain instrument webpage. It is probable that participants suddenly realized the instrument was so long that quit the instrument after responding to the first or last question of a certain instrument webpage. Therefore, the missing data falling into the monotone pattern could be missing not at random. However, the exact mechanism of the missing data still need more evidence.

For the third and fourth most frequent univariate patterns in Table 14, two participants skipped the twenty-first item, "I care what my classmates post or say in the online course" and the two skipped the second item, "The online discussion board facilitates peer interaction in the online course". These two questions were both related to online peer interaction. Likewise, I extracted the four participants' responses to demographic questions, "In the online class that you are taking, is the online discussion or collaborative learning required" and "What percentage of the time did you spend on the online discussion or collaborative learning in the whole process of the online

learning". It was found that the four participants all reported the online discussion board was set for their online classes and online peer interaction was required. In addition, on average, these participants spent 30% of class time on peer interaction or collaborative learning. No any other evidence was found to explain why they skipped the two items.

In all, two incomplete observations were found to be associated with having no online peer interaction or collaborative learning with the other classmates and the missing data falling into the monotone patterns were probably due to the webpage structure of the instrument. Thus, these missing data could be MNAR but still need more evidence to investigate the mechanism of their missingness. In the replication study, I kept the MNAR observations in the data set because the evidence supporting MNAR was inadequate and keeping them could show the variance in online learners' sense of community scores. For the other missing data patterns, there was no evidence found in descriptive analysis indicating planned missingness, so these missing data could be MAR or MCAR. Given the missing data analysis, I decided using *FIML* to deal with the missing data, because it is a commonly-used method that can provide an efficient treatment for MAR and MCAR data (Dong & Peng, 2013; Zhang & Yung, 2011).

Generalizability Evidence

Model Fit Indices

The refined bi-factor measurement model underlying the *SoC in CSCL* instrument contained instruction-related level and perceptual level. The two levels were equally represented by 24 Likert-type instrument items. The perceptual level included two constructs: *Feeling of Membership* and *Fulfillment of Needs*, which were correlated

with each other. The instruction-related level included seven factors: *Ease of Using Techniques, Close Interpersonal Connection, Senses of Self- and Collective Efficacy, Benefitting from Diverse Resources, Benefitting from Homogeneous Value, Active Peer Interaction,* and *Active Interaction with Instructors* (see Figure 4). The seven instruction-related factors were set not to correlate with one another, because they were seen as the independent factors that accounted for additional variance in the items (Reise, 2012). The refined measurement model had been confirmed in the pilot study. The replication study here was to investigate whether the bi-factor model could be replicated in a new sample via Full Information Maximum Likelihood (*CFA-FIML*) estimation. As a result, the fit statistics for this bi-factor model were acceptable (χ^2 = 436.861, *df* = 207; *RMSEA* = .076, *CFI* = .942, *TLI* = .922).

Factor Loadings

As to the factor loadings in the *CFA* output, most items had significant loadings to their perceptual constructs and instructional factors. Given the sound model fit indices and factor patterns, I can assert that online learners' sense of community in CSCL environments is predicted by their perceptions of membership and fulfillment of needs. Meanwhile, instructional interventions on learners' social interaction, task-related interaction, use of interaction techniques, and senses of self- and collective efficacy do account for additional variance in online learners' sense of community.

The loading patterns obtained in the replication study were similar to those of the pilot study, especially for items 1- 3 in *Ease of Using Techniques*, items 6 – 7 in *Close Interpersonal Connection*, items 8 – 10 in *Senses of Self- and Collective Efficacy*, items 13 – 14 in *Benefitting from Diverse Resources*, items 15 – 16 in *Benefiting from*

Homogeneous Value, items 18 – 21 in *Active Peer Interaction*. The items significantly loaded on their associated factors and constructs, which suggested that both the instruction-related factors and perceptual constructs could account for the variances of the items. In addition, items 4 in *Close Interpersonal Connection* and items 11 - 12 in *Benefitting from Diverse Resources* significantly loaded on associated perceptual constructs not on instruction-related factors, which was also similar with the results obtained in the pilot study (compare Table 10 and Table 15).

However, a few dissimilar loading patterns were also found. Item 5 in *Close Interpersonal Connection* no longer significantly loaded on the associated instruction-related factors. In addition, items 22 -24 in *Active Interaction with Instructors* turned to significantly load on both the associated instruction-related factors and perceptual constructs. In short, four of 24 items showed dissimilar loading patterns. Most loading patterns of the 24 items were similar with those obtained in the pilot study.

Compared with the literature-review-supported measurement model where the perceptual level and instructional level were proposed to account for the item variances equally, the loading patterns found in the replication study revealed minor differences. First, items 4 and 5 could be significantly explained by the *Feeling of Membership* construct, but not by the *Close Interpersonal Connection* factor. Based on the literature review, the *Close Interpersonal Connection* factor is concerned with instructors' promotion on social-emotional interaction among online learners. This instructional intervention is "getting them to know each other, committing to social relationships, developing trust and belonging, and building a sense of online community" (Kreijns, et al, 2003, p. 342). The two items stated, "My classmates in the online course are

friendly" and "I get along with my classmates very well in the online course", which assessed online learners' social relationships. However, the finding suggested that the instructional promotion on social interaction among online learners may not lead to sound social relationship. It may be because of that social relationship among online leaners, such as friendship, camaraderie, or reciprocity, is primarily influenced by other psychological factors, such as affection, kindness, love, sympathy, honesty, and so on. The other two items in the same factor, items 6 and 7 stated, "Online classmates in the online course valued my ideas or thoughts" and "My classmates in the online course always respond to my questions or thoughts in time", which assessed online leaners' relationship in task-related interaction. The two items were significantly predicted by the *Close Interpersonal Connection* factor as well as by the *Feeling of Membership* construct, which is consistent with the literature-review-supported measurement model. This finding indicated that the instructors' promotion on online learners' social interaction does facilitate them to build close relationship in learning.

Second, Item 11 and 12 were significantly explained by the *Fulfillment of Need* construct, but not by the *Benefitting from Diverse Resources* factor. Based on the literature review, *Benefitting from Diverse Resources* factor is concerned with instructional intervention on learning group composition. This intervention refers to grouping online learners from multidisciplinary backgrounds, with diverse thoughts and understanding, and with lower or higher ability in online learning. Item 11 and 12 stated, "I benefit from the diverse experiences of my classmates in the online course" and "My classmates' diverse thoughts and understandings help clarify my initial misunderstanding in the online course if there are any". The finding suggested that

online learners' need for competence was not likely to be fulfilled by exposing them to different educational backgrounds and diverse cognitive processes in online learning.

R^2

R^2 refers to the percentage of the variance in the items that can be explained by the instructional factors or the perceptual constructs. Overall, the R^2 pattern obtained in the replication study matched with the ones obtained in the pilot study (compare Table 10 and 15). Most R^2 values were high enough for the perceptual level of the bi-factor measurement model. *Fulfillment of Needs* construct and *Feeling of Membership* construct accounted for a large proportion of the variances of the 24 items, ranging from 21% to 74% (see Table 15). The item variances were explained much less by the instruction-related factors than the perceptual constructs.

In the replication study, it is interesting to find an inconsistent R^2 pattern happened in the *Active Interaction with Instructors* factor (represented by *Item 22 – Item 24*). That is, a large proportion of the item variances were explained by their instruction-related factors, ranging from 49% to 62%. Based on the literature review, the *Active Interaction with Instructors* factor is associated with the process that online instructors provide elaborative feedback and online learners respond to the feedback (Abedin et al, 2011). Elaboration feedback is not only used to verify whether students achieve learning goals in CSCL communities but also aims at improving students' learning strategies or scaffolding students' learning based on their progress in the CSCL (Cesar Coll, Rochera, & de Gispert, 2014; César Coll, Rochera, de Gispert, & Díaz-Barriga, 2013; Espasa & Meneses, 2009). The improvement and the progress make

students experience mastery on learning thus satisfies learners' need for competence (Ryan & Deci, 2000). Fulfillment of the need yields achievability for students.

Compared with the *Active Interaction with Instructors* factor, the *Active Peer Interaction* factor explained much less item variance. Based on the literature review, *Active Peer Interaction* is related to instructors' interventions on peer feedback in online collaborative learning environments, and the peer feedback promotes mutual awareness among online learners (Phielix, Prins, & Kirschner, 2010; Phielix, Prins, Kirschner, Erkens, & Jaspers, 2011). In the process of mutual awareness, individual leaners are required to provide feedback associated with group learning outcomes or the process of performing group work and respond to others' feedback to make changes to their performance in group learning. People have a need to feel they belong to their communities (Walker & Greene, 2009) so online learners are internally motivated to provide peer feedback in their CSCL communities to meet their needs of relatedness (Ryan & Deci, 2000). Compared the R^2 patterns found for the *Active Interaction with Instructors* factor and the *Active Peer Interaction* factor, I can conclude that in online learning environments, fulfillment of the need of competence more efficiently facilitates online leaners' sense of community than fulfillment of the need of relatedness.

Table 15

Factor Loadings and R^2 *Values for the Bi-Factor Model of the* SoC in CSCL *Instrument for the Replication Study*

	Instruction-Related Factors												**Perceptual Constructs**			
	ET		**IC**		**EF**		**BD**		**BH**		**PI**		**II**		**FM**		**FN**	
	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2	Loading	R^2
Item1	.52**	.27													.61**	.37		
Item2	.49**	.24													.72**	.52		
Item3	.76**	.58													.54**	.29		
Item4			.05	.00											.84**	.71		
Item5			.12	.01											.81**	.66		
Item6			.61**	.37											.70**	.49		
Item7			.49**	.24											.75**	.56		
Item8					.53**	.28									.64**	.41		
Item9					.38**	.14									.64**	.41		
Item10					.48**	.23									.66**	.44		
Item11							.00	.00									.86**	.74
Item12							.11	.01									.85**	.72
Item13							.18**	.03									.82**	.67
Item14							.48**	.23									.85**	.72
Item15									.43**	.18							.83**	.69
Item16									.32**	.10							.81**	.66
Item17									.48**	.23							.68**	.46
Item18											.26**	.07					.83**	.69
Item19											.55**	.30					.77**	.59
Item20											.29**	.08					.73**	.53
Item21											.23**	.05					.77**	.59
Item22													.79**	.62			.54**	.29
Item23													.79**	.62			.53**	.28
Item24													.70**	.49			.46**	.21

Note. ET = Ease of Using Techniques; IC = Close Interpersonal Connection; EF = Senses of Self- and Collective Efficacy; BD = Benefitting from Diverse Resources; BH = Benefitting from Homogeneous Value; PI = Active Peer Interaction; II = Active Interaction with Instructors; FM = Feeling of Membership; FN = Fulfillment of Needs

**: p <.001

Reliability Results

In this replication study, Cronbach's Alpha (α) and Omega (ω) coefficients were calculated again to indicate the internal consistency of the modified *SoC in CSCL* instrument, its underlying perceptual constructs and instruction-related factors. The scores exhibited adequate reliability for the modified instrument, $\alpha = .961$, $\omega = 967$. The reliability estimates for the constructs and factors were also good enough, ranging from $\alpha = .831$ to .953 and $\omega = .839$ to .974 (see Table 16).

Table 16

Reliability of the SoC in CSCL *Instrument for the Replication Study*

Perceptual Constructs	**Instruction-Related Factors**	**Item N**	**Mean**	***α***	***ω***
Feeling of Membership (FM)		10	6.566	.902	.952
	• Ease of Using Techniques (*ET*)	3	6.344	.885	.903
	• Close Interpersonal Connection (*IC*)	4	6.568	.873	.922
	• Senses of Self- and Collective Efficacy (*EF*)	3	6.571	.831	.839
Fulfillment of Needs (FN)		14	6.153	.953	.974
	• Benefitting from Diverse Resources (*BD*)	4	6.070	.925	.935
	• Benefitting from Homogeneous Value	3	5.831	.908	.912
	• Active Peer Interaction (*PI*)	4	5.783	.910	.915
	• Active Interaction with Instructors (*II*)	3	6.963	.921	.930

External Evidence

The purpose of correlation analysis was to provide the external evidence for validating the refined measurement model underlying the modified *SoC in CSCL* instrument. The method of providing the external evidence was investigating the degree to which online learners' scores obtained from the modified instrument were correlated with the ones from the two criterion instruments: *Intrinsic Value Instrument (IVI)* and *Self-Efficacy Instrument (SEI)*. To do that, I calculated the mean scores of the modified *SoC in CSCL* instrument, its underlying constructs and factors, and the two criterion instruments. Then, all mean scores were submitted to Pearson correlation.

The correlation results indicated that the modified instruments and the two criterion instruments were significantly correlated with one another (see Table 17), r = .307 and .338, $p < .001$. The two perceptual constructs, *Feeling of Membership* and *Fulfillment of Needs*, were also significantly correlated with the two criterion instruments respectively, r = .218, .336, .337 and .319, $p < .001$. Most instruction-related factors had significant correlations with the two criterion instruments, ranging from r = .205 to .460, $p < .001$. However, the *Ease of Using Techniques* factor and the *Close Interpersonal Connection* factor were the exceptions.

According to Cohen (1988)'s definition on the effect size of correlation, $0.1 < |r| < .3$ indicates small correlation; $0.3 < |r| < .5$ is medium correlation; and $|r| > .5$ refers to strong correlation. Therefore, the modified instrument had moderate correlations with the two criterion instruments. The correlations among the two perceptual constructs and the two criterion instruments ranged from small to medium. So were the correlation among the instruction-related factors and the two criterion instruments.

Table 17

Pearson Correlation of *SoC in CSCL*, *IVI*, and *SEI*

	SoC	**FM**	**ET**	**IC**	**EF**	**FN**	**BD**	**BH**	**PI**	**II**	**IVI**	**SEI**
SoC	1.00											
FM	.932**	1.00										
ET	.784**	.866**	1.00									
IC	.793**	.878**	.608**	1.00								
EF	.845**	.849**	.605**	.660**	1.00							
FN	.973**	.818**	.663**	.670**	.786**	1.00						
BD	.905**	.778**	.646**	.654**	.715**	.919**	1.00					
BH	.898**	.803**	.629**	.703**	.743**	.894**	.781**	1.00				
PI	.892**	.715**	.597**	.555**	.696**	.934**	.818**	.804**	1.00			
II	.637**	.500**	.390**	.371**	.543**	.673**	.482**	.470**	.532**	1.00		
IVI	.307**	.218**	.130	.126	.312**	.337**	.283**	.211**	.276**	.458**	1.00	
SEI	.338**	.336**	.205**	.244**	.460**	.319**	.286**	.265**	.236**	.343**	.490**	1.00

Note. Instruments: SoC = SoC in CSCL Instrument; IVI = Intrinsic Value Instrument; SEI = Self-Efficacy. Perceptual constructs: FM = Feeling of Membership; FN = Fulfillment of Needs. Instruction-related factors: ET = Ease of Using Techniques; IC = Close Interpersonal Connection; EF = Senses of Self- and Collective Efficacy; BD = Benefitting from Diverse Resources; BH = Benefitting from Homogeneous Value; PI = Active Peer Interaction; II = Active Interaction with Instructors.
**: $p < .001$

Conclusion

The bi-factor measurement model was statistically refined and the *SoC in CSCL* instrument was accordingly modified through five versions in the pilot study. Results presented in this chapter were used to validate the refined measurement model underlying the modified instrument in a new sample. I provided generalizability evidence, reliability estimate, and external evidence for the validation and accordingly answered the following three research questions.

The research question 3-1 investigated how the refined measurement model underlying the modified instrument is explained by new observed data. The *CFA* result showed that with minor differences, the measurement model confirmed in the replication study was similar with the one refined in the pilot study. The replication of

the measurement model in the new sample provides the generalizability evidence for validating the SoC in CSCL instrument. Therefore, it can be asserted that the refined measurement model was replicated in a different sample to maintain scientific integrity so that the sense of community in CSCL observed in the instrument can be generalized to a universe of expected sense of community in CSCL that the instrument aims at measuring (Burman, Reed, & Alm, 2010; Kane, 2016).

The replicated measurement model indicates that in an online collaborative learning community, online learners' sense of community is generated from their feeling of membership and fulfillment of needs. In addition to the two perceptual constructs, seven instruction-related factors can also account for online leaners' sense of community in CSCL environments. The instruction-related factors are concerned with instructors' promotion on online learners' feeling of membership (i.e., getting them use interaction tool smoothly, value their participation in online interaction, and be confident in achieving collaborative learning goals). In addition, the factors are also associated with instructors' facilitation on online learners' fulfillment of need of competence and need of relatedness. The satisfied needs intrinsically motivate online learners to bond closely with one another to do online collaborative learning.

The research question 3-2 refers to the extent to which scores on items in the modified *SoC in CSCL* instrument show internal consistency. Both the Cronbach's alpha coefficient and Omega coefficients were calculated to provide the reliability estimates. Compared to Cronbach's alpha, Omega takes the correlation between items and constructs as well as item-specific measurement errors into account, so it provides a better estimate of reliability for an instrument (Peters, 2014). Therefore, in the

replication study, Omega was computed to provide another reliability estimate. As a result, the reliability estimates for the modified instrument and its underlying perceptual constructs and instruction-related factors were all above the acceptable levels for both Cronbach's alpha ($\alpha \geq .80$) and Omega ($\omega \geq .80$). The adequate reliability estimates indicated that the instrument items produced internally consistent scores.

Research question 4 was to provide the external evidence for validating the refined measurement model. Since the *SoC in CSCL* instrument is designed to specifically assess online learners' sense of community in CSCL, the extrapolation inference is indispensable to investigate whether the assessed sense of community in CSCL can be extended to the expected perception the instrument aims to measure (Messick, 1989; Kane, 2016). The correlation results showed that online learners' scores obtained from the two criterion instruments, *Self-efficacy Instrument* and *Intrinsic Value Instrument,* were significantly correlated with their scores on the modified *SoC in CSCL* instrument as well as its underlying two perceptual constructs and most instruction-related factors. The sound external evidence indicates that the modified instrument measures what it aims.

Chapter 6: Findings, Conclusions, and Implications

The purpose of Chapter 6 is to summarize the research needs, purposes, questions, and findings. Specifically, I will summarize why this study was conducted, the research goals and questions, how these research questions were answered via data collection and analyses, and results of the study. After that, implications and future research avenues will be discussed.

Summary of the Study

Review of Research Needs

In recent years, with the advancement of communication technology, rising costs, shrinking budgets, and diverse enrollments in education, online courses are widely used. However, online courses were often seen as isolated, inhuman, and anti-social (Stahl et al., 2006). Computer-Supported Collaborative Learning (CSCL) arose in the 1990s in response to the problem of isolated online learning (Stahl et al., 2006), because CSCL has positive effects on promoting motivation, critical thinking, shared understanding, retention of acquired knowledge, and students' engagement in the construction of new ideas and concepts (Benbunan-Fich, 1997; Garrison et al., 2001; Johnson & Johnson, 1999; Slavin, 1990).

However, recent research has shown negative consequences of CSCL (Azevedo, 2007; de Jong et al., 2005; Salovaara, 2005). The causes for the negative consequences could be limitations of CSCL itself (Azevedo, 2007; de Jong et al., 2005; Salovaara, 2005), learners' emotional alienation (Kreijns, et al., 2003; Wendt & Rockinson-Szapkiw, 2015), and instructors' pedagogical stereotyping of instructional design (Kreijns et al., 2003). Among these causes emotional alienation refers to the feeling of

social isolation, powerlessness, and normlessness (Dean, 1961). In online learning communities, physical separation among online learners is inevitable and learning time is asynchronous (Morgan & Tam, 1999). In addition, online educators and instructional designers often neglect instructional interventions for online learners' emotional connections (Kreijns, et al, 2003). Hence, emotional alienation is more likely to happen in online learning communities. Sense of community is considered one solution to the problem of emotional alienation (Palloff & Pratt, 1999), because it can stimulate strong motivation, high-quality interaction, more critical thinking, and positive learning outcomes in online collaborative learning (Abfalter et al., 2012; Haythornthwaite & Wellman, 1998; Rovai, 2002b; Townley et al., 2013; Tu & Corry, 2002).

Research Purposes and Questions

The dual purposes of this study are to 1) identify the theoretical framework of the concept of sense of community in CSCL based on a comprehensive literature review, and 2) use the theoretical framework as a measurement model to develop an instrument exhibiting reliability and validity. Specifically, the following research questions were addressed:

1. What is the measurement model of the new *SoC in CSCL* instrument?
2. How is the literature-review-supported measurement model supported by statistical evidence?
    1) How is the literature-review-supported the measurement model underlying the new *SoC in CSCL* instrument explained by observed data?
    2) Are scores obtained from the *SoC in CSCL* instrument reliable?
3. Can the refined measurement model be replicated in a new sample?

1) How is the refined measurement model underlying the modified *SoC in CSCL* instrument explained by observed data?
2) Are scores obtained from the modified *SoC in CSCL* instrument reliable?

4. Are online learners' scores on the two criterion instruments, *Self-Efficacy Instrument* (*SEI*) and *Intrinsic Value Instrument* (*IVI*), highly correlated with their scores on the modified *SoC in CSCL* instrument?

Research Procedures

To answer the research questions, I first explored the theoretical framework of the concept of sense of community in CSCL environments via conducing a comprehensive literature review. Second, I conducted a pilot study, using the theoretical framework as a measurement model to draft the new instrument, distributing the initial instrument version online, and analyzing how the measurement model was explained by the observed data. Then, I refined the measurement model based on the results of the pilot study and also modified the instrument through five versions. After that, a replication study was forwarded. I refit the refined measurement model in a new sample. Cronbach's Alpha (α) and Omega (ω) coefficients were calculated to assess the internal consistency of the modified instrument and its underlying perceptual constructs and instruction-related factors. The correlations between the criterion instruments: *Intrinsic value Instrument* and *Self-Efficacy Instrument*, the modified instrument, and its underlying constructs and factors were analyzed to provide the external evidence for validating the modified instrument.

Overview of Findings and Conclusion

Exploration of the Measurement Model

The measurement model underlying the *SoC in CSCL* instrument contains two equal levels. McMillan (1996) and McMillan and Chavis (1986) proposed a theoretical framework for the concept of sense of community, which consists of four perceptual constructs. I contextualized the four constructs for online collaborative learning communities: *Sense of Membership, Perception of Influence, Fulfillment of Needs,* and *Emotional Connection*. This four-construct framework functions as the perceptual level of the measurement model. Later, according to the four-construct framework and empirical research in the field of CSCL, I explored eleven instruction-related factors that are associated with the four perceptual constructs. The comprehensive literature review gave evidence that the instruction-related factors can promote online learners' emotional connection and productive learning outcomes in CSCL environments. Therefore, I identified eleven instruction-related factors for the measurement model.

Pilot Study

A pilot study was conducted to answer how the measurement model was supported by statistical evidence. To provide the evidence, I created the first instrument version based on the measurement model, which contained 60 eight-point Likert-type items. The instrument was distributed to the students who were taking online courses for data collection and analyses. The resulting measurement model and the instrument were modified through five versions. Specifically, the two equal conceptual levels were kept for the refined measurement model. The perceptual level contained two constructs and the instruction-related level contained seven factors. In addition, I accordingly deleted the instrument items to generate a sound instrument version.

Replication Study

Given the refined measurement model, a replication study was conducted to investigate whether the model would fit data collected from a new sample so that we could confidently confirm the measurement model. In the replication study, I provided generalizability evidence, reliability estimates, and external evidence to validate the measurement model. Specifically, first, I submitted the new observed data to *CFA* analysis using *FIML*. The *CFA* result showed that despite of minor differences, the measurement model was similar with the one refined in the pilot study. Second, the reliability estimates of the modified instrument and its underlying perceptual constructs and instruction-related factors all reached the acceptable levels of Cronbach's alpha and Omega. The sound reliability estimates indicated the instrument items produced internally consistent scores. Third, correlation analyses were conducted to compare the constructs and factors underlying the *SoC in CSCL* instrument with two criterion instruments. As a result, online learners' scores obtained from the two criterion instruments were significantly correlated with their scores from the modified *SoC in CSCL* instrument as well as its underlying two constructs and most factors. The correlation results provided the external evidence for validating the measurement model. Therefore, it can be asserted that the *SoC in CSCL* instrument measures what the instrument aims to measure.

Given sound statistical evidence in the replication study, we can confidentially confirm the two-level measurement model. The confirmed measurement model suggests that in a CSCL community, online learners' sense of community is generated from their feeling of membership and fulfillment of needs. The sense of community also yields from their experience on smoothly using interaction tool, mutually valuing their

participation in online interaction, achieving collaborative learning goals, and fulfilling their needs of competence and relatedness in online learning environments.

Implications

Theoretical Implications

This research has implications for theoretical development. A two-level theoretical framework was generated from a comprehensive literature review to profile sense of community in CSCL environment. The theoretical framework contains four perceptual constructs and eleven instruction-related factors. Based on quantitative data analyses, the theoretical framework was revised and confirmed, and eventually two perceptual constructs and seven instruction-related factors were kept.

In light of the gap between the theoretical proposal and statistical output, first, I found that as to online learning communities, some of constructs and factors were conceptually overlapping with the others. For example, the *Emotional Connection* construct was deleted because statistical results showed that the construct respectively shared a common variance with the *Adaptation to Group Regulation* factor, the *Efforts for Group Consensus* factor, and the *Achievability from Contribution to Group Success* factor. According to McMillan and Chavis (1986)'s theory, this construct was defined as being emotionally connected to each other through sharing events that end with positive consequences, and the positive consequences could be active interaction, getting tasks resolved, valuing shared events, intimacy, honor, and spiritual bond. In CSCL communities, online interaction and collaborative learning are the primary events, so emotional connection forms when online leaners engage in collaborative learning activities. The statistical results suggested that in CSCL communities, the

emotional connection could be embedded in group regulation, group consensus on knowledge understanding and decision making, and productive knowledge construction.

Second, revisions to the proposed theoretical framework suggested that in online learning communities, some perceptual constructs and instruction-related factors played less important role in promoting sense of community than they did in geographic communities. For instance, the *Adaptation to Group Regulation* factor and the *Efforts for Ground Consensus* factor were deleted, because the statistical results showed that their underlying items were insufficient to explain the variances of associated factors. Based on the literature review, in geographic communities, the two factors reflect a bidirectional psychological process, i.e., perceiving the pressure from communities to conform themselves with others and the capability to influence others in communities (McMillan & Chavis, 1986; McMillan, 1996). However, in CSCL communities, conform knowledge understanding and problem solutions are necessary to finish collaborative learning tasks, but the conformity should be conflict-oriented (Weinberger & Fischer, 2006). In other words, simply accepting others' ideas or taking over others' perspectives is not the advocacy of CSCL; instead, sharing diverse perspectives through active interaction are always encouraged for knowledge construction. Hence, in CSCL communities, the perceived pressure to conform oneself with other learners plays less important role in facilitating sense of community.

Instructional Implications

This study also has implications for instructional practice. First, although the sample sizes in the pilot study and the replication study were not large, it is still possible to develop the profile of the concept of sense of community in CSCL via statistically

confirming the measurement model underlying the *SoC in CSCL* instrument. The confirmed measurement model indicated that online learners' sense of community in CSCL is concerned with their feelings of membership and need satisfaction. These feelings yield from their online learning experience with positive consequences, which is consistent with McMillan & Chavis (1986) and McMillan (1996)'s claim that community members are tied with each other emotionally through sharing events that end with positive consequences. The positive consequences could be active interaction, getting tasks resolved, valuing shared events, intimacy, honor, and spiritual bond. In CSCL environments, the positive consequences are using communication techniques smoothly, being intimate with online classmates, getting collaborative learning tasks done, benefiting from more competent co-learners, sharing similar cultural background, and active interaction with peers and instructors. Online instructors can design corresponding instruction intervention to promote the positive consequence, such as, providing easy navigation of online communication interface, scaffolding social interaction among online learners, grouping students with low- and high- learning ability or students with same cultural background, providing elaborative feedback to online group work, requiring peer feedback in CSCL communities.

Second, it is particularly interesting that the *Close Interpersonal Connection* factor did not significantly predict the associated items. *Close Interpersonal Connection* is concerned with instructors' promotion on social-emotional interaction among online learners (i.e., "getting them to know each other, committing to social relationships, developing trust and belonging, and building a sense of online community"; Kreijns, et al, 2003, p. 342). In order to promote social interaction among online learners,

instructors usually incorporate face-to-face meetings into online courses. Due to the lack of early face-to-face communication, online learners often lack the ability to form correct impressions and close bond with one another necessary for online collaborative learning (K. Kreijns et al., 2003; Wendt & Rockinson-Szapkiw, 2015). Through face-to-face meetings, online learners share social and affective information to update their impression entries to bond with each other. However, the finding in the replication study suggested that interventions faculty use to promote social interaction did not promote bonding among online learners. This may be because social relationships among online leaners, such as friendship, camaraderie, or reciprocity, are primarily influenced by other psychological factors (e.g., affection, kindness, love, sympathy, or honesty). Therefore, this finding implies that grouping learners who have formed emotional bond with each other may be more efficient to promote their sense of community than just providing face-to-face meetings. This implication is supported by Cho, Gay, Davidson, and Ingraffea (2007)'s research on the relationship between communication styles, social networks, and learning performance in a CSCL community. They found that pre-existing friendship significantly affected the way learners built social networks in online collaborative learning.

The third interesting finding is that the *Active Interaction with Instructors* factor accounted for more variance in the associated item scores than the *Active Peer Interaction* factor. This finding suggests that interaction with instructors may play a more important role in predicting online learners' sense of community than peer interaction. Based on literature review, *Active Interaction with Instructor* improves online learners' learning strategies and online learning outcomes thus satisfies the

learners' need for competence (Ryan & Deci, 2000). *Active Peer Interaction* factor facilitates mutual awareness among online learners via providing and responding peer feedback (Phielix, et al., 2010). People have a need to feel they belong to their communities (Walker & Greene, 2009) so online learners are internally motivated to provide peer feedback in their CSCL communities to meet their relatedness needs (Ryan & Deci, 2000). Therefore, I can conclude that in online learning environments, fulfillment of the need of competence more efficiently facilitates online leaners' sense of community than fulfillment of the need of relatedness. This conclusion suggests that active peer interaction cannot exclusively lead to a strong sense of community in CSCL environments, and instructors should pay more attention to how to scaffold online learners' interaction. Scaffolding of learners' interaction is necessary because without any scaffolding, peers are more likely to engage in communications unrelated to the learning tasks or basic information clarification. Although active communication exists, peer interaction will likely exhibit a shallower thought process in message threads in the online discussion interface. Hence, the mutual awareness among online group learners may also stay at a shallow level, inhibiting sense of community. This implication is supported by Kearsley (1995) and Liaw and Huang (2000)'s claim that peer interaction should be specifically designed by instructors in order for it to be meaningful. In addition, Kreijn and his colleagues (2003) asserted that communication techniques could not exclusively make deep peer interaction occur automatically.

Limitations

Although this dissertation study successfully confirms the measurement model using validity evidence and accordingly develops a new instrument exhibiting reliability

and validity, there are some limitations. First, the sample size is not large. Less than 10% of the instructors initially contacted allowed me to recruit their online students. Among the students who received the recruitment email from their instructors, in the pilot study, only 206 agreed to participate. In the replication study, 192 online students had access to the online instrument and only 162 students completed all items. To encourage more students to participate in both the pilot study and the replication study, I provided raffle drawings for the participants to win one of ten gift cards with 50 dollars. In an attempt to increase the sample size, I contacted one instructional designer who designs online courses for some colleges at the university and the Dean of one college at the university to aid in distribution of recruitment materials to instructors teaching in online course. More work is needed to enlarge the sample in future studies, such as, extending the data collection pool to other educational settings.

Second, Item 6 in the demographic questions was designed poorly. This item asked for participants to give their major by choosing from a short list of options (i.e., *Physical Science, Life Science, Engineering, Social Science, Humanities, Arts, and Others*). The frequency result showed that 50% of the participants in the pilot study and 47.9% in the replication study chose the *Other* option. This result suggested the other six options available for this question did not cover the range of majors provided by this university very well, so it is hard to investigate the extent to which the samples collected in the two studies represented the population of the university. In this case, the college options listed in the Enrollment Summary that is annually reported by the University could replace the major options for this question.

Third, although drafts of the instrument were written based partially on the advice of instructors and students who had online instruction and learning experience, some instructors who had access to the instrument used in the study pointed out awkward terms used in some items after I distributed the modified instrument. For example, Item 15 stated, “I have a similar learning style as my classmates in the online course”. “Learning style” was pointed out as an awkward term that might cause confusion to students. Hence, the awkward terms should be replaced and a specific survey assessing the readability of the modified instrument should be designed to provide content validity evidence for the modified instrument.

Fourth, sound external evidence was provided to demonstrate convergent validity through investigating the correlations between scores obtained from the SoC in CSCL instrument and scores from two related criterion instruments. However, the evidence for discriminant validity is lacking in the present study. In contrast to the convergent validity, the purpose of gathering evidence of discriminant validity is to ascertain the extent to which instruments assessing constructs unrelated to the construct of interest exhibit the expected relations (Messick, 1989). A thorough literature review should be conducted to explore the factors not related with online learners’ sense of community in CSCL to investigate their correlation with sense of community. Non-significant correlations will indicate sound discriminant evidence.

Future Research

Despite these limitations, this study was an important first step to develop an instrument specific to sense of community in CSCL environments. Several future research avenues can be forwarded, which refer to follow-up measurement

development, exploring factors that can influence online learners' sense of community, and investigating the impact of instructional interventions on online learners' sense of community.

First, data should be continuously collected in new samples to provide generalizability evidence for validating the new instrument. With this, the instrument should be continuously revised along with the update of validity evidence (Messick, 1995). Specifically, to investigate whether the measurement model replicates in new samples, data collection should be extended to other universities. The new data can be submitted to CFA to refit the measurement model underlying the instrument.

Second, a mixed-method study can be conducted to explore the psychological factors promoting and impeding online learners' sense of community. Specifically, students exhibiting both strong and weak sense of community in their online courses based on response to the *SoC in CSCL* instrument can be interviewed to investigate the specific events happened in the online courses promote or impede their feeling of membership and fulfillment of needs. These factors could then be explored to further investigate online learners' sense of community in CSCL environments.

Third, this research has implications for instructional practice, such as scaffolding social interaction, grouping students with same cultural background, providing elaborative feedback to online group work, and so on. Specific instructional interventions can be tested to ascertain their influence on online students' sense of community and collaborative learning performance. Students' sense of community can be assessed via the well-developed *SoC in CSCL* instrument. Collaborative learning performance can be analyzed via intensity of their online interaction and achievement of

collaborative learning tasks. These empirical research findings could function as a reference for online educators to better understand online learners' perceptions and needs in CSCL communities and design specific instructional interventions to enhance their interaction, collaboration, and productivity in CSCL.

Summary

This dissertation study has explored the theoretical framework of the concept of sense of community in CSCL and used the theoretical framework as a measurement model to develop an instrument to a sound version. This dissertation study makes an important contribution to the research field of CSCL. The confirmed measurement model helps online educators to understand online learners' psychological needs in CSCL environments, and the production of an instrument with reliable and valid scores provides a sound measurement tool for online educators to assess their students' sense of community and design associated instructional interventions to promote their online collaborative learning performance. Even so, the study has limitations, specifically in the areas of sample size, demographic question design, and word choice in design item statement. In the follow-up measurement development, these limitations should be solved. Once the limitations are addressed, future research can proceed. Next steps include conducting a mix-method study to explore the factors promoting and impeding online learners' sense of community in CSCL environments and comparing effect of different instructional interventions on students' sense of community and collaborative learning performance in CSCL environments.

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Appendices

Appendix A: The First *SoC in CSCL* Instrument Version

Demographic Questions

1. Your gender

- ❍ Male
- ❍ Female
- ❍ Other Gendered _____

2. Age

- ❍ 16-25 years
- ❍ 26-35 years
- ❍ 36-45 years
- ❍ 46-55 years
- ❍ 56-65 years
- ❍ 66-75 years
- ❍ 76 or more years

3. Ethnicity

- ❍ African American/Black
- ❍ Asian/Asian American
- ❍ Pacific Islander/Native Hawaiian
- ❍ Hispanic/Latino
- ❍ Native American/American Indian
- ❍ White/Caucasian
- ❍ Other _____

4. Enrollment Status

- ❍ Full-time student
- ❍ Part-time student

5. Your current registration status

- ❍ Degree seeking
- ❍ Certificate seeking
- ❍ Non-degree seeking

6. Your major

- ❍ Physical science
- ❍ Life science
- ❍ Engineering
- ❍ Social science
- ❍ Humanities
- ❍ Arts
- ❍ Other

7. How many online courses or study programs have you taken in addition to the course currently taking?

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ More than 4

8. Please indicate how much you agree or disagree with each statement by clicking on the response that corresponds with your previous online learning experience

I am satisfied with my previous online learning experience:

- ❍ Strongly Disagree (1)
- ❍ Moderately Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Slightly Disagree (4)
- ❍ Slightly Agree (5)
- ❍ Somewhat Agree (6)
- ❍ Moderately Agree (7)
- ❍ Strongly Agree (8)

9. In the online class that you are taking, is the online discussion or collaborative learning required?

❍ Yes

❍ No

10. Did you participate in any online discussion or collaborative learning though they are not required in the class that you are taking?

❍ Yes

❍ No

11. What percentage of the time did you spend on the online discussion or collaborative learning in the whole process of the online learning?

_____ Percentage (%)

***SoC in CSCL* Instrument**

Please indicate how much you agree or disagree with each statement by clicking on the response that corresponds with your previous online learning experience

I am satisfied with my previous online learning experience:

❍ Strongly Disagree (1)

❍ Moderately Disagree (2)

❍ Somewhat Disagree (3)

❍ Slightly Disagree (4)

❍ Slightly Agree (5)

❍ Somewhat Agree (6)

❍ Moderately Agree (7)

❍ Strongly Agree (8)

Feeling of Membership

Close Socio-Emotional Relationship

1. My classmates in the online course are friendly.

2. I value what my classmates posted or said in the online course.

3. I get along with my classmates very well in the online course.

Sense of Ease

4. The communication interface in the online course is user-friendly.

5. The online discussion board facilitates peer interaction in the online course.

6. The online course has convenient access to the online discussion board.

7. I feel my classmates care what I posted or said in the online course.

8. My classmates in the online course value my ideas or thoughts.

9. My classmates in the online course always respond to my questions or thoughts in time.

Senses of Self- and Collective Efficacy

10. I am certain that I am doing well in the online course.

11. Although facing challenges, I still can find ways to succeed in the online course.

12. I consider the online course an opportunity for me to learn more about the subject.

13. I belief my online classmates and I have enough knowledge and skills to complete an online collaborative learning task.

14. I am confident that my online classmates and I are capable of collaboratively achieving a preset online learning goal.

15. My classmates and I are all doing well in the online course.

Perception of Influence

Adaptation to Group Regulation

16. My classmates and I synthesize divergent ideas into a common form.
17. My classmates help focus my attention to learning tasks.
18. My online classmates and I have a shared understanding of course materials or co-constructed problem solutions.

Efforts for Group Consensus

19. I try to persuade my online classmates to agree with me if I find a conflict of opinions between my classmates and me.
20. I want to compare my ideas presented in the online course with my classmates' to unify our understanding of course materials or problem solutions.
21. I am not certain whether or not my ideas and opinions can influence my classmates' in the online course.

Fulfillment of Needs

Sense of Leadership to Group Learning

22. I clearly know my role in collaborative learning tasks of the online course.
23. I actively take on my responsibilities for collaborative learning tasks of the online course.
24. I am committed to the work assigned to me in collaborative learning tasks of the online course.
25. I provide elaboration feedback to my classmates' work in the online course.

26. I am comfortable to point out and correct my classmates' misunderstanding in the online course.
27. I feel comfortable to bring in more resources to share with my classmates in the online class.

Benefitting from Diverse Resources

28. I benefit from the diverse experiences of my classmates in the online course.
29. Sharing information with my classmates provides me new perspectives to gain deeper understandings of course materials in the online course.
30. My classmates' diverse thoughts and understandings help clarify remove my initial misunderstandings of course materials in the online course if there are any.
31. I value the support from my classmates who are more competent than me in the collaborative learning of the online course.
32. The competent classmates positively influence me in terms of staying motivated and working on online collaborative learning tasks.
33. I help the classmates who are struggling or need help in the online course.

Benefitting from Homogeneous Value

34. I have a similar learning style as my classmates in the online course.
35. I am consistent with my online classmates on what is desirable and important for the online course.
36. I value the online course the same way as my online classmates do.

Achievability from Contribution to Group Success

37. The achievement of my individual learning goals has an impact on the attainment of my group learning goals in the online course.
38. If I cannot complete the work that my online learning group assigned to me, I feel bad about that.
39. If I contribute to achievement of collaborative learning tasks, I am proud of that.
40. I enjoy the interaction with my classmates in the online course.
41. I am happy when I see an active peer interaction happens in the online course.
42. Active peer interactions promote my participation in the online course.
43. I am happy when I see my classmates become more and more motivated in the collaborative learning of the online course.
44. I am happy when I see my online classmates' positive emotion in the online course.
45. My online classmates' motivational changes influence my motivation in the online course.
46. I want to get elaborative feedback from the instructor of the online course because she/he can guide my online individual/group learning in the online course.
47. The instructor's feedback is important for me to evaluate my individual/group online learning progress.
48. I enjoy discussing with my instructor on how to make progress for my individual/group online learning.

Emotional Connectedness

Cognitive Awareness

49. I am clear about whether or not my group members have enough relevant knowledge or skills to complete the collaborative learning task(s) of the online course.
50. I know the knowledge gap before working on collaborative learning task(s) with my online classmates.
51. It is necessary to know each group member's relevant prior knowledge or skills before working on the collaborative learning task(s) of the online course.
52. I care about how the other group members evaluate my work in the collaborative learning task(s) of the online course.
53. My classmates' feedback on my work in the online course is very helpful.
54. I just finish the work assigned to me and I do not care about how my classmates evaluate my work in the collaborative learning task(s) of the online course.

Social Awareness

55. I care what my classmates post or say in the online course.
56. I am clear about who substantially contributes to the collaborative learning in the online course.
57. I do not care whether my classmates actively participate in the online collaborative learning.
58. I am aware of my classmates' personalities.
59. I am happy when I find that my classmates are willing to collaborate with each other in the online course.
60. I like to look for the creativity in my classmates' ideas and thoughts in the online course because it inspires me.

Win a $50 Amazon Gift Card!

In order to appreciate your participation, a raffle drawing will be held for ten $50 gift cards. Please input your email address in the following box. Your contact email will not be linked to your responses and will only be used for notifying the raffle winners. If you do not want to input your email address, you still can participate in the research. Please click the button " >> " to complete the survey.

End Messages

For people who click “I agree to participate” at the bottom of the Consent Form: We thank you for your time spent on taking this survey! Your response has been recorded.

For people who click “I do not want to participate” at the bottom of the Consent Form: Thank you very much for your time and consideration.

Appendix B: The Fifth *SoC in CSCL* Instrument Version and the Two Criterion Instruments *IVI* and *SEI*

Demographic Questions

1. Your gender

- ❍ Male
- ❍ Female
- ❍ Other Gendered _____

2. Age

- ❍ 16-25 years
- ❍ 26-35 years
- ❍ 36-45 years
- ❍ 46-55 years
- ❍ 56-65 years
- ❍ 66-75 years
- ❍ 76 or more years

3. Ethnicity

- ❍ African American/Black
- ❍ Asian/Asian American
- ❍ Pacific Islander/Native Hawaiian
- ❍ Hispanic/Latino
- ❍ Native American/American Indian
- ❍ White/Caucasian
- ❍ Other _____

4. Enrollment Status

- ❍ Full-time student
- ❍ Part-time student

5. Your current registration status

- ❍ Degree seeking
- ❍ Certificate seeking
- ❍ Non-degree seeking

6. Your major

- ❍ Physical science
- ❍ Life science
- ❍ Engineering
- ❍ Social science
- ❍ Humanities
- ❍ Arts
- ❍ Other

7. How many online courses or study programs have you taken in addition to the course currently taking?

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ More than 4

8. Please indicate how much you agree or disagree with each statement by clicking on the response that corresponds with your previous online learning experience

I am satisfied with my previous online learning experience:

- ❍ Strongly Disagree (1)
- ❍ Moderately Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Slightly Disagree (4)
- ❍ Slightly Agree (5)
- ❍ Somewhat Agree (6)
- ❍ Moderately Agree (7)
- ❍ Strongly Agree (8)

9. In the online class that you are taking, is the online discussion or collaborative learning required?

❍ Yes

❍ No

10. Did you participate in any online discussion or collaborative learning though they are not required in the class that you are taking?

❍ Yes

❍ No

11. What percentage of the time did you spend on the online discussion or collaborative learning in the whole process of the online learning?

_____ Percentage (%)

***SoC in CSCL* Instrument**

Please indicate how much you agree or disagree with each statement by clicking on the response that corresponds with your current online learning experience

Strongly Disagree (1)

Moderately Disagree (2)

Somewhat Disagree (3)

Slightly Disagree (4)

Slightly Agree (5)

Somewhat Agree (6)

Moderately Agree (7)

Strongly Agree (8)

Feeling of Membership

Ease of using online techniques:

1. The communication interface in the online course is user-friendly.

2. The online discussion board facilitates peer interaction in the online course

3. The online course has convenient access to the online discussion board.

Close interpersonal connection:

4. My classmates in the online course are friendly

5. I get along with my classmates very well in the online course

6. My classmates in the online course value my ideas or thoughts

7. My classmates in the online course always respond to my questions or thoughts in time

Sense of Efficacy

8. I belief my classmates and I have enough knowledge and skills to complete an online collaborative learning task

9. My classmates and I are all doing well in the online course

10. I clearly know my role in online collaborative learning tasks

Fulfillment of Needs

Benefitting from Diverse Resources

11. I benefit from the diverse experiences of my classmates in the online course

12. My classmates' diverse thoughts and understandings help clarify remove my initial misunderstanding in the online course if there are any.

13. I value the support from my classmates who are more competent than me in online collaborative learning

14. The competent classmates positively influence me in terms of staying motivated and working on online collaborative learning tasks

Benefitting from Homogeneous Value

15. I have a similar learning style as my classmates in the online course

16. I am consistent with my online classmates on what is desirable and important for the online course

17. I value the online course the same way as my online classmates do

Active Peer Interaction

18. I enjoy the interaction with my classmates in the online course

19. Active peer interactions promote my participation in the online course

20. My online classmates' motivational change also influences my motivation in the online course.

21. I care what my classmates post or say in the online course.

Active interaction with Instructors

22. I want to get elaborative feedback from the instructor of the online course because she/he can guide my online individual/group learning in the online course

23. The instructor's feedback is important for me to evaluate my individual/group online learning progress

24. I enjoy discussing with my instructor on what has been done and what can be done in order to make progress for my individual/group online learning

Intrinsic Value Instrument (*IVI*) and Self-Efficacy Instrument (*SEI*)

Please indicate how much you agree or disagree with each statement by clicking on the response that corresponds with your perceptions of intrinsic value and self-efficacy about your current online learning experience.

(1) Not at all true of me

(2)

(3)

(4)

(5)

(6)

(7) Very true of me

Intrinsic Value

25. I will be able to use what I learn in this online course in other courses

26. It is important for me to learn the course materials in this online course

27. I am very interested in the content area of this online course

28. The course materials is useful for my future study

29. I like the subject matter of this online course

30. Understanding the subject matter of this online course is very important to me

Self-Efficacy

31. I believe I will receive a good grade in this online class

32. I'm certain I can understand the most difficult material presented in the readings for this online course

33. I'm confident I can learn the basic concepts taught in this online course

34. I'm confident I can understand the most complex course materials

35. I'm confident I can do an excellent job on the assignments in this online course

36. I'm certain I can master the skills being taught in this online course

37. Considering the difficulty of this online course, the teacher, and my skills, I think I will do well in this online course

Appendix C IRB Research Approval

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Study Modification – Expedited Review – AP0

Date: October 27, 2016 **IRB#:** 6856

Principal Investigator: Lihui Liao **Reference No:** 658019

Study Title: Validating Theoretical Constructs of Sense of Community in Computer-Supported Collaborative Learning Environment (CSCL)

Approval Date: 10/26/2016

Modification Description:
1. Revise the online survey, including grammatical errors and the online unsigned consent form at the first page of the online survey
2. Add interview information in application form. The modification there has been highlighted in yellow
3. Add interview information in line 18 and 21 of the online unsigned consent form and upload the signed consent form for the interview
4. Add interview information in the protocol and highlighted the modification
5. Add interview information in recruitment emails for professors and upload a specific recruitment email for the interview

The review and approval of this submission is based on the determination that the study, as amended, will continue to be conducted in a manner consistent with the requirements of 45 CFR 46.

To view the approved documents for this submission, open this study from the My Studies option, go to Submission History, go to Completed Submissions tab and then click the Details icon.

If the consent form(s) were revised as a part of this modification, discontinue use of all previous versions of the consent form.

If you have questions about this notification or using iRIS, contact the HRPP office at (405) 325-8110 or irb@ou.edu. The HRPP Administrator assigned for this submission: Karen Braswell.

Cordially,

Fred Beard, Ph.D.
Vice Chair, Institutional Review Board

Appendix D Recruitment Email for Online Instructors and Professors

Dear professor,

My name is Lihui Liao. I am a doctoral student in the Department of Educational Psychology in the Jeannine Rainbolt College of Education, under the direction and guidance of my advisor, Dr. Maeghan Hennessey (maeghan@ou.edu). I am writing to ask for your approval for me to recruit your students from your online course(s) of this semester to participate in my study.

The purpose of this study is to explore students' sense of community in online collaborative learning. Their experiences in this online course can offer me important insights that are necessary to explore what factors can promote interaction and knowledge construction in online collaborative learning environment and thus improve future online education programs.

Your students' involvement in this study is voluntary and will consist of the completion of an online survey and possible participation of a follow-up interview. The online survey includes questions about students' four perceptions: sense of membership, perception of influence from the other group members, motivation, and emotional connection with the other members. The follow-up interview will ask how they behave with a strong sense of community in the online course and how their strong sense of community forms. If your online course(s) involve(s) online discussion or collaborative learning, please forward the following recruitment email to the students who enrolled your online course(s) and inform me of that action. Your students can access to the online survey via clicking the link attached in the recruitment email. Upon completion of the study, the students who agree to participate will be given the opportunity to enter

a raffle for ten $50 Amazon gift cards. No identifying information about either the participants or course instructors will be collected as part of the survey.

I will appreciate your help and time if you allow me to recruit your students.

Sincerely,

Lihui Liao

Appendix E Recruitment Email for Students

Help Improve Online Education!

Win an Amazon Gift Card!

Dear student,

I am writing to ask for your participation in an online survey of students' sense of community in computer-supported collaborative learning (*SoC in CSCL*). You are selected as a potential participant because you are taking an online course.

Your experience in this online course offers important insights that are necessary for me to explore the factors that can promote interaction among learners and knowledge construction in CSCL and thus improve future online education programs.

Your involvement in this study is voluntary and will include completion of an online survey. It will require approximately 15-20 minutes to complete. Your participation information and responses will not be shared with your professors or instructors of the online course. In order to maintain the anonymity of responses, no personal identifying information will be collected as part of the survey.

At the end of the survey, you will be given the opportunity to enter a raffle for one of 10 Amazon gift cards. To enter the raffle, please input your contact email at the end of the survey. Your contact email will not be linked to your responses in the online survey. Contact emails will only be used for notifying the raffle winners and will be deleted right after the gift cards are distributed. You can still participate in the research even if you do not want to provide your contact email.

Please click here to take the online survey. Or copy paste following link in address bar: https://ousurvey.qualtrics.com/SE/?SID=SV_9ttUbLnQEPAGmzj

Thank you for your time and consideration.

The OU IRB has approved the content of this advertisement but the investigator is responsible for securing authorization to distribute this message by mass email.

Sincerely,

Lihui Liao

Appendix F Consent Form

Online Consent to Participate in Research

Would you like to be involved in research at the University of Oklahoma?

I am Lihui Liao from the Educational Psychology Department and I invite you to participate in my research project entitled Validating Theoretical Constructs of Sense of Community in Computer-Supported Collaborative Learning Environment (CSCL). This research is being conducted at University of Oklahoma. You are selected as a possible participant because you are taking an online course or learning program. You must be at least 18 years of age to participate in this study.

Please read this document and contact me to ask any questions that you may have BEFORE agreeing to take part in my research.

What is the purpose of this research? The purpose of this research is to explore the theoretical constructs associated with students' sense of community in CSCL and validate these theoretical constructs.

How many participants will be in this research? About 500 people will take part in this research.

What will I be asked to do? If you agree to be in this research, you will be asked to complete an online survey. Based on the survey result, you may be contacted by email to participate in a follow-up interview.

How long will this take? Your will take approximately 15-20 minutes to complete the online survey. If you participate in the follow-up interview, it will take approximately 20-30 minutes.

What are the risks and/or benefits if I participate? There are no risks and no benefits from being in this research.

Will I be compensated for participating? You will be reimbursed for your time and participation in this research. At the end of the online survey, you may fill out your contact emails for the raffle drawing. Filling out your contact emails is voluntary and your email address will not be linked to your responses in the online survey. Ten raffle winners will be awarded $50 Amazon gift card.

Who will see my information? In research reports, there will be no information that will make it possible to identify you. Research records will be stored securely and only approved researchers and the OU Institution Review Board will have access to the records.

Do I have to participate? No. If you do not participate, you will not be penalized or lose benefits or services unrelated to the research. If you decide to participate, you don't have to answer any question and can stop participating at any time.

Who do I contact with questions, concerns or complaints? If you have questions, concerns or complaints about the research or have experienced a research-related injury, contact me at 405-365-9268 and llh@ou.edu, or my advisor, Dr. Maeghan N. Hennessey at 405-325-3574 and maeghan@ou.edu.

You can also contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at 405-325-8110 or irb@ou.edu if you have questions about your rights as a research participant, concerns, or complaints about the research and wish to talk to someone other than the researcher(s) or if you cannot reach the researcher(s).

Please print this document for your records. By providing information to the researcher(s), I am agreeing to participate in this research.

- I agree to participate (click should connect to survey)
- I do not want to participate (click should connect to a Thank You for considering page)

This research has been approved by the University of Oklahoma, Norman Campus IRB.

IRB Number: ___6856_____ Approval date: __10/27/2016_____

(NOTE: The Principal Investigator is responsible for the input of the IRB number and approval date, BEFORE the document is implemented online.)