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Analyzing Social Construction of Knowledge and Social Networks in Online Discussion Forums in Spanish

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**ANALYZING SOCIAL CONSTRUCTION OF KNOWLEDGE AND SOCIAL
NETWORKS IN ONLINE DISCUSSION FORUMS IN SPANISH**

By

David Raúl Gómez Jaimes

DISSERTATION

Submitted in Partial Fulfillment of the
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DEDICATION

To España Antonielli Valentina Josefina, for her love, faith, words of wisdom, and infinite patience helped me to learn the strength and courage it takes to make it to the end of a journey like this one. I will be forever owe gratitude to the sacrifices España made as a spouse, as a friend, as a partner, and as a mother. To Bruno Valentino, your arrival to this planet transformed my world and your existence has filled my days and nights with pure love; it takes a joyful sound to make the world go round, this sound my beloved son is the sound of your heart beating, your smiles, and your cries; your very existence is the answer to the miracle of life.

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ABSTRACT

This mixed methods research project examined social construction of knowledge and social networks in three non-structured student centered online discussion forums, which were part of a graduate online course on web conferencing in Spanish within the Mexican sociocultural context. The purpose of the study was to identify interaction patterns among twenty-one graduate students by analyzing discussion forum posts, measuring student centrality, and generating social network diagrams in order to explain the characteristics of posts and social networks that may contribute to social construction of knowledge.

The researcher used a sequential approach, starting with the application of an interaction analysis model and social network analysis, followed by a combination of both analyses to shed light on interaction in online discussion forums carried out in Spanish. The researcher found evidence of interaction patterns that suggest a possible relationship between the centrality measure in-degree and high levels of social construction of knowledge, furthermore results suggest dissonance or disagreement in student-to-student interaction may

also contribute to the achievement of more complex phases of social construction of knowledge.

Keywords: Online Discussion Forums, Social Construction of Knowledge, Centrality, Interaction Analysis, Social Network Analysis, Mixed Methods

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CHAPTER ONE: PROBLEM STATEMENT

Online courses lend themselves well to social constructivist instruction by providing students with opportunities to discuss ideas, work in teams to solve cases, problems, projects, and even assess themselves and their peers, which is part of the reason why online courses are as critical to the long-term strategy of higher education institutions around the world, as face-to-face courses. Furthermore, learning management systems and their user activity tracking and content archiving capabilities allow researchers to study online interaction among students in a relatively inexpensive way, technically speaking.

In this vein, what is the best way to orchestrate discussion forums that foster interaction in an online course? A current conundrum both in undergraduate and graduate online courses is interaction among students that leads to social construction of knowledge as suggested by Lucas, Gunawardena, and Moreira (2014), who report that in spite of a myriad of studies related to student-to-student interaction in online discussion forums, there is inadequate literature about the orchestration of discussion forums that foster interaction aimed at generating social construction of knowledge.

Social construction of knowledge is a phenomenon defined by Gunawardena, Lowe and Anderson (1997) as a function of interaction, which is understood as a reciprocal influence among individuals that engage in online interaction. Like a patchwork quilt, interaction is the collection of unique messages sewn together, resulting in socially constructed knowledge.

There are three themes in the literature about student-to-student interaction in online discussion forums, namely: 1) studies focused on the process of knowledge construction e.g., Chai and Tan (2009), 2) social networks e.g., Gottardo and Noronha (2012), and 3) a

combination of both e.g., Toikkanen and Lipponen (2011). However, most studies offer basic explanations of student-to-student interaction or do not provide practical solutions to the orchestration of discussion forums that promote interaction, as described in the literature review in chapter two.

For instance, researchers focused on the process of knowledge construction rely heavily on the analysis of discussion forum transcripts missing the big picture, while those focused on social networks rely heavily on Social Network Analysis (SNA), which does allow them to derive student centrality, but leads them to produce reductionist diagrams of interaction. In this context, student centrality is a concept that accounts for the social aspect of knowledge construction in the sense it accounts for interaction dynamics. According to Wasserman and Faust (1994), the centrality of individuals in a social network can be obtained with centrality measures and social network diagrams that depict interaction patterns, thus the researcher used centrality as an indicator of student influence on other students.

Few researchers have studied both knowledge construction and social networks, including student centrality, through mixed methods e.g., Aviv, Erlich, Ravid, and Geva (2003); Li (2009); and Buraphadeja (2010); who in spite of the epistemological challenge associated with mixed methods were able to reach a more complete view of online interaction and provide some answers to the conundrum of student-to-student interaction in discussion forums.

Researchers, online instructors and students, instructional designers, and university leaders may benefit from the study of social construction of knowledge in discussion forums by gaining insight into their orchestration, especially considering the discussion forum tool is

the quintessential communication technology deployed by online instructors to promote interaction among students, particularly to discuss new ideas.

Social construction of knowledge is a term associated with the concept of Social Constructivism, which is not a learning theory *per se*, but a concept that originates from Social Learning and Constructivism. This concept is a perspective in itself and it gives special importance to social interaction, through which a community of individuals shares and constructs knowledge. From this perspective, knowledge construction is often considered a matter of acculturation (Duffy and Cunningham, 1996), furthermore, this view assumes "learning is collaborative with meaning negotiated from multiple perspectives" (Smith and Ragan, 2005, p. 20).

Social Learning emphasizes the importance of observing and modeling behaviors, attitudes, and emotional reactions of others, as Bandura (1977) stated:

Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action. (p. 22)

In short, Social Learning explains human behavior in terms of continuous reciprocal interaction between cognitive, behavioral, and environmental influences.

On the other hand, a major argument in Bruner's (1966) Constructivism is that learning is a process, through which individuals construct new ideas or concepts upon their current and/or previous knowledge, therefore they select and transform information, construct hypotheses, and make decisions, relying on a cognitive structure. Thus,

Constructivism is a general framework for instruction based on the study of cognition that considers the importance of social aspects.

In his more recent work, Bruner (1986, 1990, 1996) expanded Constructivism to encompass the social and cultural aspects of learning. This expanded view is in line with Vygotsky (1997), who is also prominent in the literature on social and cultural aspects of learning with his work on the differences between lower (natural) and higher (cultural-historical) mental functions, in which he suggests "every higher mental function was external because it was social before it became an internal, strictly mental function" (p. 105). In addition, the social cultural perspective suggests both enculturation and acculturation are learning factors. So, it is worth clarifying that while enculturation is the way through which an individual is brought up in the traditional ideas, practices, and values of the community in which she was born and raised; acculturation is the way through which an individual assimilates the traditional ideas, practices, and values of another community.

However, social constructivist instruction is not limited to "sharing a workload or coming to a consensus, but allows learners to develop, compare, and understand multiple perspectives on an issue," (Karagiorgi and Symeou, 2005, p. 21) and it should involve sharing, discussion, argumentation, reflection, and often negotiation. As a result, social constructivist instruction can accommodate large or small groups, or an entire community of practice.

Successful and innovative organizations around the globe are increasingly collaborative and they value collaboration as a critical skill. Individualistic efforts both in the workplace and at school are being channeled in favor of collaborative efforts. Collaboration is an idea that goes back to the social origins of learning associated with Vygotsky's (1978)

social cultural perspective, in which he proposed there is a cognitive distance known as Zone of Proximal Development between what individuals know and can do independently, and what individuals can potentially achieve with the assistance of a more capable person. Therefore, learning is culturally mediated through a process of both internalization of knowledge and enculturation that occurs while interacting with others.

Constructivism is a useful lens to study social construction of knowledge by focusing on interaction associated with internalization of knowledge. To understand social construction of knowledge is to understand Constructivism and its theoretical foundations, which were laid by Jean Piaget (1929), John Dewey (1938), Lev Vygotsky (1997), and Ernst von Glasersfeld (1989), who set the stage for the idea that "learning is an active process occurring in realistic and relevant situations, it results from a personal interpretation of experience, and an exploration of multiple perspectives" (Richey, Klein and Tracey, 2011, p. 144).

In this vein, interaction among individuals is a fundamental ingredient for social construction of knowledge and the one factor that has motivated instructors of online courses to consider the best of both—Social Learning and Constructivism—worlds in the implementation of learning activities through a variety of communication tools such as discussion forums because they provide a place where ideas and views on a particular issue can be exchanged. According to Dawson (2006), the high degree of incorporation of the discussion forum tool in online courses indicates that it provides a valuable communication channel for instructors and students.

In addition, Dawson and MacWilliam (2008) suggested that monitoring the quantity of student participation in a discussion forum is a lead indicator of student learning

performance. Likewise, Dawson, McWilliam, and Tan (2008) identified that the most dominant tool used across a university that offered online courses was the discussion forum, representing over 80 percent of all student interaction, and even though the quantity of student posts in a discussion forum is revealing, the occurrence of social construction of knowledge in discussion forums is more relevant for educational purposes.

Researchers focused on assessing social construction of knowledge face a phenomenon that is ultimately an individual cognitive process, i.e., a process of internalization of ideas, which develops in relation to a group through social interaction. For instance, as course members collaborate, their individual ideas about tasks, constructs, and the group itself become more aligned with one another because humans learn from observing others. To reiterate, students construct knowledge both socially and individually based on their interpretations, so it is crucial for researchers to examine how centrality—as defined by SNA—relates to the process of social construction of knowledge in discussion forums.

As stated earlier, researchers, online instructors and students, instructional designers, and university leaders need to gain insight into the orchestration of discussion forums that foster student-to-student interaction. Therefore, examining social construction of knowledge in discussion forums is a challenge that deserves systematic investigation.

Purpose of the Study

This mixed methods research project examined social construction of knowledge and social networks in three non-structured online discussion forums, which were part of a graduate online course on web conferencing. The purpose of the study was to identify student-to-student interaction patterns by analyzing discussion forum posts, measuring

student centrality, and generating social network diagrams in order to explain characteristics of posts that lead or contribute to social construction of knowledge.

To approach said interaction patterns, the researcher used the Interaction Analysis Model created by Gunawardena et al. (1997)—commonly referred to as IAM—to determine if students constructed knowledge through interaction in discussion forums. In addition, the researcher utilized SNA to measure student centrality according to Wasserman and Faust (1994) in order to account for the social aspect of knowledge construction.

Graphing the structure of the social network that emerges from a discussion forum with social network diagrams is a way of graphing interaction patterns with the ultimate purpose of identifying posts that provide potential interaction sequences to high levels of knowledge construction.

Significance

The mixed methods research project presented here was aimed at advancing the academic study of social construction of knowledge in online discussion forums previously reported by Aviv, Erlich, Ravid, and Geva (2003), Li (2009), and Buraphadeja (2010), who demonstrated the adequacy of combining the Interaction Analysis Model and SNA. The relevance of supplementing the Interaction Analysis Model with measures of student centrality and social network diagrams that depict interaction patterns lies on the ability to advance previous studies not only by accounting for the social aspect of knowledge construction in social network terms, but by examining empirical data in Spanish within the Mexican sociocultural context.

The researcher specifically addressed Buraphadeja's (2010) recommendations for researchers to apply SNA's centrality measures as a way to supplement the assessment of

knowledge construction in online discussion forums in the sense these centrality measures along with social network diagrams may provide researchers with a broader and deeper understanding of the social aspects of social construction of knowledge. Furthermore, the researcher addressed Buraphadeja's (2010) suggestion to utilize the Interaction Analysis Model in a different educational setting that involved the examination of discussion forum transcripts in Spanish generated within the Mexican sociocultural context.

Thus, the researcher applied SNA assuming centrality measures are a good indicator of a student's degree of influence over other students in a discussion forum, and considering social network diagrams offer a graph of interaction patterns. The study of social construction of knowledge and social networks in the context of online courses may inform scholars about the characteristics of discussion posts and the degree of student centrality associated with potential interaction sequences to high levels of knowledge construction.

Online instructors and instructional designers who develop online courses may find suggestions on the application of social constructivist principles to the design of discussion forums capable of fostering interaction. Also, this study may offer some clarification on the alignment of discussion forums as a learning activity with the expected level of social construction of knowledge as set by course and/or learning objectives.

Discussion forums possess a resilience, technologically speaking, that appeals to online instructors because they facilitate the exchange of ideas and expressions of agreement and disagreement related to social construction of knowledge, which is a value that has been at the core of the mission of western universities for centuries.

Therefore, an explanation of social construction of knowledge and social networks could be beneficial in the sense it can shed some light on how to orchestrate online

discussion forums that foster interaction through posts, which may pave interaction sequences to high levels of knowledge construction.

This study is grounded on a constructivist perspective. Even though some scholars use the term paradigm (Lincoln & Guba, 2000; Mertens, 1998), epistemology or ontology (Crotty, 1998), the researcher selected the term perspective to denote the way he makes sense of knowledge and conceptualizes it through the lens of Constructivism. Thus, he selected the Interaction Analysis Model created by Gunawardena et al. (1997) because it is grounded on a social constructivist theoretical foundation that is consistent both with his perspective and the nature of the problem statement. On the other hand, the researcher chose SNA to supplement the Interaction Analysis Model by accounting for the social aspect of knowledge construction in terms of social networks, i.e., it accounts for interaction dynamics based on the idea an information flow co-exists with a social relationship among students. By mixing both methods, the researcher was able to illustrate the abstract process of knowledge construction in a more complete way, taking into consideration the totality of interconnected relations that emerge from online discussion forums.

The researcher's constructive perspective lead him to choose specific strategies of inquiry and research methods as suggested by Crotty's (1998) framework. These strategies go hand in hand with his assumptions as to how humans construct knowledge, namely:

- meanings are constructed by human beings as they engage with the world they are interpreting
- humans engage with their world and make sense of it based on their historical and social perspectives

- the basic generation of meaning is always social, arising in and out of interaction with a human community

Thus, the research methods the researcher chose to explain social construction of knowledge and social networks in online discussion forums allowed him to provide both a qualitative answer and a quantitative one. Furthermore, he was able to deliver a more complete explanation by mixing both methods because they explore the phenomenon in question better together in the sense SNA supplements the Interaction Analysis Model by accounting for the social aspect of knowledge construction.

In a nutshell, the main epistemological difference between the selected research methods is that while the Interaction Analysis Model is an abstract way of outlining the process of social construction of knowledge and it is rooted in a theoretical framework based on Social Constructivism, SNA is a perspective rooted in sociology and social psychology. Nevertheless, both methods share the capacity to examine interactions or relationships among social entities and their patterns.

It is worth highlighting the fact interaction itself is the overlap between the Interaction Analysis Model and SNA because interaction involves an information flow that coexists with a social relation among students. This overlap allowed the researcher to mix the two approaches to provide a more complete explanation of social construction of knowledge in the sense SNA supplements the Interaction Analysis Model by accounting for the social aspect of knowledge construction with evidence of the basic generation of knowledge arising in and out of interaction within social networks of students that emerge from online discussion forums. Epistemological differences between the two methods are described in

more detail in the literature review in chapter two under the section named Online Interaction and Social Network Analysis.

Research Question

1. How does social construction of knowledge relate to student centrality as defined by SNA in Spanish online discussion forums conducted in Mexico?
 - 1a. Does knowledge construction occur through student-to-student interaction in online discussion forums as measured by the IAM?
 - 1b. What are the characteristics of the social network created by students in an online discussion forum?
 - 1c. What are the characteristics of posts published by students with high centrality?
 - 1d. Does higher student centrality contribute to a higher level of social construction of knowledge?

Delimitations

The online discussion forum marked the limits of this study, so the researcher only examined transcripts of discussion forums. These discussion forums are in Spanish, as they were generated by graduate students from a Mexican university, who were native speakers of Spanish. The researcher focused on student interaction because the discussion forum is by far the most predominant tool online instructors rely on to foster student-to-student interaction in online courses. Generally speaking, online instructors, students, and administrators consider discussion forums as a fundamental component of both learning and socialization in online distance education, or in other words, as the common denominator of online courses regardless of the subject, yet there is not a "one size fits all" standard of discussion forum.

The researcher set out to obtain transcripts of discussion forums from a graduate online course because online instructors typically expect students to engage in dialogue as a means of knowledge construction, so the researcher concentrated on studying discussion forums in depth, as opposed to covering more ground taking into consideration other sources of data, such as surveys, quizzes, interviews, journals or assignments. In this type of research project, a constructivist perspective seems particularly useful for researchers who have a vested interest in finding tangible evidence of the basic generation of knowledge arising in and out of interaction within a student community.

The researcher focused on the selected population, described in detail in the methodology in chapter three, because most studies have been focusing on English speaking students from developed countries and only a small number of research reports examined transcripts in a different language, for instance in Spanish. The researcher also noticed that the vast majority of studies focused on undergraduate courses, but only a small number of studies focused on graduate courses or professional development.

From a constructivist point of view, the researcher assumed a graduate online course in a North American university, such as a Mexican one, which has officially gone through a process of internationalization, provides a learning environment where knowledge is constructed by students through dialogue as they engage with the world they are interpreting and making sense of based on their historical and social perspectives, i.e., their mindset. This is the essence of discussion forums. For example, in the process of social construction of knowledge as defined by the Interaction Analysis Model, the fourth phase (one before the highest level of knowledge construction) suggests a student would test someone else's idea against her mindset to co-construct new knowledge.

Therefore, the researcher did not consider culture *per se* as a determinant aspect of social construction of knowledge, but expected it to be an emerging aspect in the analysis, which lead him to inform Gunawardena's (2013) study of culture in online learning as a complex issue that includes factors such as language, values, and beliefs. To clarify, culture and its impact on intercultural communication in online learning was not within the scope of this study because it is a different phenomenon in itself.

The researcher aimed at finding methodological middle ground in mixed methods because such a research design would inform his perspective with both subjective and objective analyses of data by contrasting qualitative results with quantitative results, and he conducted a multiple regression as an extra step to verify the extent to which centrality measures explain the variability of the social construction of knowledge level. For instance, the researcher selected SNA as a sound quantitative technique because it measures student centrality, accounting for the social aspect of social construction of knowledge. To reiterate, centrality is understood as "a measure of the importance of an actor in a social network" (Wasserman and Faust, 1994, p. 170). Thus, the researcher focused on whole networks, as opposed to ego networks, and on one-mode data, as opposed to two-mode data, and last but not least he focused on directed ties measured as valued ties that can be stronger or weaker, or transmit more or less information, or have more or less frequent contact.

This study paid special attention to online interaction as defined by the Interaction Analysis Model by Gunawardena et al. (1997), which is not to be confused with Jordan and Herderson's (1995) definition of Interaction Analysis as the examination of "interaction of human beings with each other and with objects in their environment. It investigates human activities, such as talk, nonverbal interaction, and the use of artifacts and technologies" (p.

39) because online communication in the form of discussion forum posts is not talk (speech). Furthermore, Gunawardena et al.'s (1997) model is different from Content Analysis, which is a quantitative technique the researcher did not use. The differences between the Interaction Analysis Model, Interaction Analysis as defined by Jordan and Henderson (1995), and Content Analysis as defined by Krippendorff (2004) are explained in more detail in chapter two.

Limitations

Other than discussion forum transcripts from an online graduate course, there was a lack of available data from other sources, such as surveys, journal entries, tests, to mention a few examples of data that can be archived in online courses. This lack of available data required the researcher to limit the scope of his study to online interaction in discussion forums only.

Hypothetically speaking, had the researcher had access to other data, for example to student surveys or follow up interviews, this sources of information would have enhanced the study in the sense the researcher could have been able to triangulate information. Moreover, the researcher thinks it is probable that other sources of data would have confirmed the fact that the instructional design of the discussion forums did not ask much of them in terms of social construction of knowledge and likely in terms of engagement.

A multiple regression was run as an extra step to verify the extent to which centrality measures explain the variability of the social construction of knowledge level, but results should not be generalized to a particular population because the number of cases used in the statistical test was minimum. However, thanks to the study's design, results should have transferability to similar contexts and settings. Also, the researcher relied on a dataset of pre-

existing and de-identified data, which is limited in that he could not ask follow up questions to the people who generated the data, therefore he had to take what discussion forum transcripts said at face value. Although this type of dataset is something humans produced, institutional review boards and social scientists refer to them as web-based secondary datasets.

Principles that guide SNA limit its scope in the sense the researcher has to make certain assumptions to describe and explain a phenomenon like social construction of knowledge. For example, the researcher looked at relations, not attributes of people such as age or income, because the answer to the research question was not located solely in a particular individual, but in the social network/structure that emerges from an online discussion forum. Also, the researcher used the social network approach to examine networks within a group of people not the group of people as a whole *per se*, which involves making sense of people's centrality within networks, but not of people's centrality within the group. Furthermore, he examined relations in a relational context, meaning he examined interaction patterns of a social network, not just relations between pairs, which allowed the researcher to account for the broader patterns of ties within the network to address the totality of interconnected relations that emerge from online interaction in a discussion forum.

In terms of educational culture and philosophical bias the researcher acknowledges a reliance on constructivism, and social constructivism as some of the "best" perspectives available to approach both the orchestration of online discussion as well as the design of online courses with a visible enthusiasm for high quality instruction based on diversity, student initiative and self-direction, collaboration, and integration of tools that foster social construction of knowledge.

Definition of Terms

Centrality. A measure of the importance of an actor in a social network (Wasserman and Faust, 1994. p. 170). Generally speaking, the quality of being at the core or heart of something.

Centrality Measures. A group of metrics in Social Network Analysis that quantify the relevance of an individual in a social network based on her position within a group.

Distance Education. "Teaching and planned learning in which the teaching normally occurs in a different place from learning, requiring communication through technologies, as well as special institutional organization" (Moore and Kearsley, 2012, p. 2) such as correspondence courses, televised classrooms, radio education.

Face-to-face Education. Conventional classroom course where no online technology is used and content is delivered in writing or orally.

Interaction, student-to-student. Communication among students that takes place through discussion forums in online courses and it refers to Moore's (1989) definition of learner-learner interaction. Moore (1989) categorized interaction in three different types in the context of distance education: learner-learner interaction, learner-content interaction, and learner-instructor interaction.

Interaction Analysis. The examination of "interaction of human beings with each other and with objects in their environment. It investigates human activities, such as talk, nonverbal interaction, and the use of artifacts and technologies" (Jordan and Henderson, 1995, p. 39).

Interaction Analysis Model (IAM). A qualitative research technique developed by Gunawardena, Lowe, and Anderson (1997) to assess social construction of knowledge by examining computer mediated communication transcripts.

Learning Management System. An online system designed to provide educators, administrators and individuals with a single robust, secure, and integrated environment to create and implement online learning.

Online Course. A type of course where at least 80% of content is delivered online.

Online Discussion Forum. A communication tool available in most learning management systems, which allows students and online instructors to interact with each other by posting and replying to messages.

Online Learning. Teaching and planned learning in which the teaching specifically occurs through online courses and resources.

Social Construction of Knowledge. A phenomenon defined by Gunawardena et al. (1997) as a function of interaction, which is understood as a reciprocal influence among individuals that engage in dialogue online.

Social Constructivism. A concept and a view that emphasizes the importance of culture and context in constructing knowledge. As a view derived from both Social Learning and Constructivism, it puts forward the idea that knowledge is both an internal process and a social construct, which is mediated by language through social interaction.

Social Network Analysis. The graphing and measuring of relationships and flow of information among individuals.

CHAPTER TWO: LITERATURE REVIEW

The literature review revolved around the phenomenon of social construction of knowledge through interaction in discussion forums in the context of graduate online courses, so the researcher focused on reading publications about distance education theory and peer-reviewed articles on social construction of knowledge as well as SNA in online discussion forums, which lead the researcher to classify literature in three categories. The first category includes studies that applied the Interaction Analysis Model by Gunawardena et al. (1997), the second included studies that used SNA, and the third a combination of both, i.e., mixed methods studies. The researcher excluded from his literature review studies about K-12 education, open university online courses, and studies that were not set in the context of formal education. He did include some studies about blended learning and hybrid courses if they examined transcripts of discussion forums orchestrated by instructors to foster student-to-student interaction online. He also included studies published both in English and Spanish.

In this vein, the researcher presents in this chapter a literature review of social construction of knowledge and centrality—as defined by SNA—in discussion forums in the context of higher education online courses. The researcher took into consideration seminal publications, textbooks, and research papers in order to show the rationale behind a mixed methods research project that explains social construction of knowledge and social networks.

Literature on social construction of knowledge revealed that on the one hand, several researchers that applied Gunawardena et al.'s (1997) Interaction Analysis Model validated its adequacy to study social construction of knowledge as a function of student-to-student interaction in online discussion forums (e.g., De Wever, Van Keer, Schellens, and Valcke, 2010; Heo, Lim, & Kim, 2010; and Chai & Tan, 2009). However, the Interaction Analysis

Model lacks breadth of analysis because it does not have a way of accounting for the social aspect of knowledge construction, so it misses "the big picture" that could be obtained by graphing interaction patterns. Furthermore, the aforementioned researchers described the model inconsistently by calling it content or discourse analysis and they were also inconsistent with the definition of the unit of analysis. Nevertheless, these researchers were able to determine instances of social construction of knowledge in online discussion forum posts.

On the other hand, researchers that applied SNA to online discussion forums validated its adequacy to a certain extent (e.g., Dawson, Bakharia, Lockyer, and Heathcote, 2011; and Dawson, Bakharia, and Heathcote, 2010) because they only focused on the social aspect of interaction and explained who wrote to who, but did not do an in-depth analysis of posts, so they missed specific occurrences of knowledge construction. Still, the aforementioned researchers were able to describe student centrality and provide diagrams of interaction patterns.

The common theme of mixed methods studies is the combination of either content analysis, discourse analysis or the Interaction Analysis Model with SNA based on the idea that certain interaction patterns contribute differently to the social construction of knowledge process that develops in online discussion forums.

Online Courses

In U.S. Higher Education, around one in four students (28%) took at least one online course in 2015. Online students equaled a total of 5,828,826 students, which represented an annual increase of 3.9% compared to the 3.7% rate recorded in 2014. The total of 5.8 million online students included 2.85 million that took all of their courses online and 2.97 million

that took some online courses. Public universities have the largest proportion of online students, with 72.7% of all undergraduate and 38.7% of all graduate-level students according to Allen and Seaman (2016).

In their 13th annual report of the state of online learning in U.S. Higher Education, Allen and Seaman (2016) found although the proportion of university leaders that say online courses are critical to their long-term strategy fell from 70.8% in 2014 to 63.3% in 2015, the proportion that rate the learning outcomes in online courses as the same or superior to those in face-to-face courses was at 71.4% in 2015. Furthermore, only 29.1% of university leaders reported that their faculty accept the value and legitimacy of online courses, as defined by Allen and Seaman's (2016) survey, and colleges with the largest online enrollments 60.1% reported faculty acceptance while only 11.6% of the colleges without online enrollments reported so.

Online Discussion Forums

"To have discussion for discussion's sake is not good instructional design. The discussions within an online distance education course must be well orchestrated to enable the learner to meet the learning outcomes, and build knowledge and insights" (Shearer, 2013, p. 257)

The first scholars to recognize online communication had the potential to represent a new generation of distance education were Lauzon and Moore (1989), who paved the way for many studies on online and asynchronous group communication. For example, Kearsley (1995) studied questions related to online interaction, particularly, related to the effects of the frequency of interaction, types of students, subject matter, alignment of interaction and learning objectives, and the effects of interaction on student satisfaction.

Two decades later, Moore and Kearsley (2012) published what would become a standard textbook on distance education in the USA, in which they devoted a chapter to technologies and media that included a section about learning management systems where they state online instructors "...have found the most valuable feature to be the asynchronous threaded discussion forum in text format. A discussion forum allows students and instructors to interact by posting and reading messages, while each has the flexibility regarding when they do it" (p. 81).

Moore's (2013), work is without a doubt a scholarly reference on online distance education, for example it includes a chapter on interaction in the context of online courses, which presents a revamped version of his seminal idea of modes of interaction, namely: student-teacher interaction, student-to-student interaction, and student-content interaction. Moore (2013) concludes this chapter stating "although interaction among students has been studied most frequently, the various the [sic] forms and combinations of interaction discussed here would benefit from systematic and rigorous research using a variety of research tools and methodologies" (p. 365).

Thus, it is worth pointing out the conundrum the researcher presented in his problem statement: what is the best way to orchestrate discussion forums that foster interaction in an online course? This is still a challenge both in undergraduate and graduate online courses as interaction among students may lead to social construction of knowledge. This challenge has been approached by researchers such as Auyeung (2004), Ke and Carr-Chellman (2006), and Ke and Xie (2009) from angles different than social construction of knowledge.

For instance, a case study conducted by Auyeung (2004) reported the use of the bulletin board feature to implement a simulation game in a hybrid course in WebCT, a

proprietary learning management system (LMS), where students role-played characters and discussed issues online. A descriptive and evaluative examination was conducted concerning how the online instructional design principles and practices were integrated into a social science general education course and how the students' learning was impacted. The researcher used a survey and found that "90% of students reported that they gained from either actively participating in the online discussion or from just reading others' messages" (p. 119).

Likewise, a phenomenological study conducted by Ke and Carr-Chellman (2006) explored the experiences of five isolated (with little or no interaction with other learners) in an online course. The researchers found that isolated learners experienced both cognitive and affective responses in their course. For example, this excerpt from participant P5 said: "While it was interesting to read other classmates' ideas, sometimes I felt confused by too many different opinions. I didn't know which one to believe. And frankly, this exercise [reading others' postings] had little effect on my concept of the mindtool by this point. I would read the book several times and figure it out" (p. 256). This excerpt suggests that timely feedback was necessary either from the instructor or another student as a factor for effective communication online.

A causal-comparative case study conducted by Ke and Xie (2009) examined the impact that different types of interaction in online discussions have on adult learners' perceptions of learning and their interaction performance. The study's differences were not statistically significant, however results indicated "student-student discussions, in comparison with student-to-instructor ones, predicted higher satisfaction, more social interactions, more high-level knowledge-constructive interactions, more reflection-oriented

interactions, and potentially a stronger sense of community" (p. 7). The researchers considered this as an initial attempt to explore learning environment approaches that positively impact adult learners.

The problem researchers like Auyeung (2004), Ke and Carr-Chellman (2006), and Ke and Xie (2009) had with the study of different ways to orchestrate discussion forums from such angles was that student-to-student interaction needs to be examined not only for how it happens, its frequency or timeliness, but in terms of the intent and form, i.e., interaction needs to be examined in terms of social construction of knowledge.

Social Construction of Knowledge

Social construction of knowledge is a phenomenon defined by Gunawardena et al. (1997) as a function of interaction, which is understood as a reciprocal influence among individuals that engage in dialogue. Like a patchwork quilt, interaction is the collection of unique messages sewn together, which result in socially constructed knowledge.

Social Constructivism is a concept that derives from both Social Learning and Constructivism as shown in Figure 1.

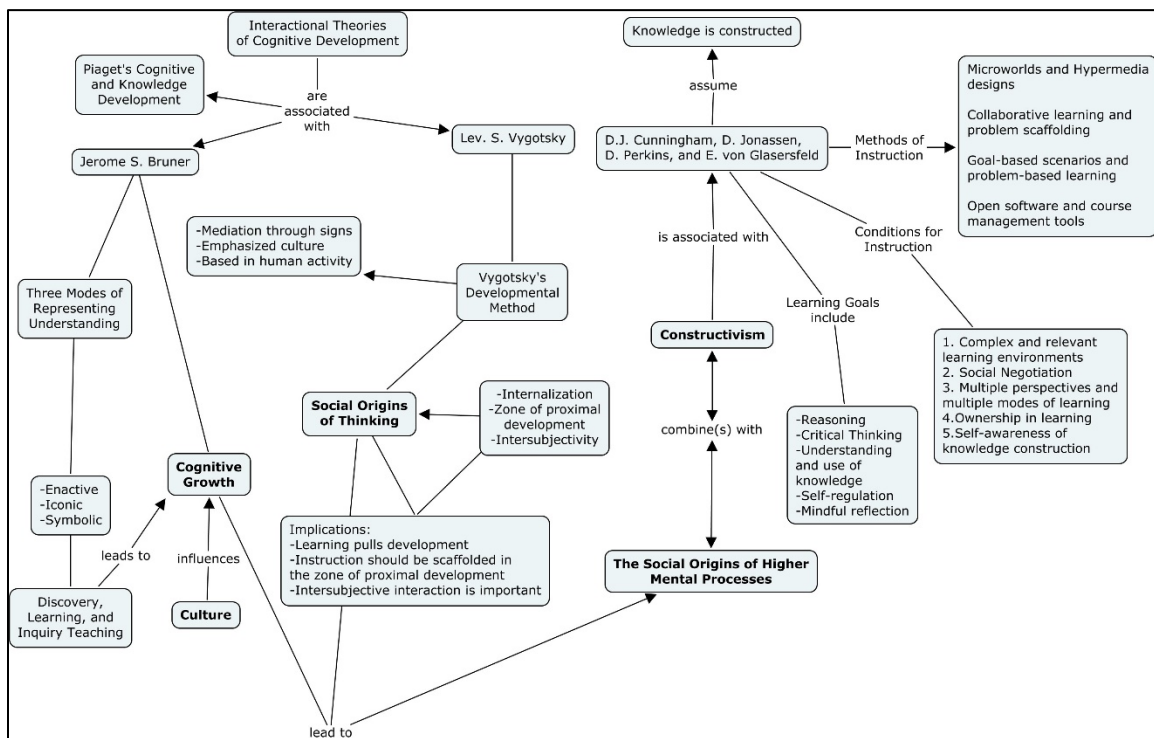


Figure 1 Social Constructivism Concept Map by Gomez (2012)

Bruner's (1960) Constructivism and the concept of Zone of Proximal Development developed by Vygotsky (1978) were considered as interactional theories of cognitive development, which entail learning outcomes such as thinking, conceptual knowledge, ability to use the tools of one's culture, and awareness of one's own thinking to interact with the instructor, peers, and the sociocultural environment to solve problems. In addition, "the role

of the instructor is to engage learners in socially organized labor activities relevant to their culture with learning partners appropriate for the desired goals of instruction" (Driscoll, 2005, p. 262).

Wertsch (1991) drew on the work of Vygotsky (1978) to outline an approach to mental functioning that stresses its intrinsic cultural, historical, and institutional context. A critical characteristic of this approach relates to the cultural tools or mediational means that shape both social and individual processes.

Active Learning emerged from the constructivist point of view with the work of Perkins (1992). This approach involved interacting with information at a high level, building on top of this information, and interpreting it in light of one's previous knowledge and experiences. Also, constructivist instructional designers commonly used open-ended assessments to determine if individuals understood and could apply knowledge they had constructed for themselves.

Duffy and Cunningham (1996) complemented the aforementioned ideas with their work on Cognitive Apprenticeship. They suggested that the important aspect of this approach is for the individual to operate as a member of a larger community of practice, who through legitimate peripheral participation and the affordances of the environment, begins to assume greater responsibility in that community.

With Jonassen's (1997) seminal Problem Solving model—commonly known as Problem-based learning (PBL)—a clear emphasis was then placed on internal processes and individual differences that impact PBL. Based on his topology of problems, the internal conditions impacting problem solving, and knowledge of how humans solve problems, Jonassen (1997) proposed a learning model for well- and ill-structured problem solving. If

the outcome is for students to learn how to solve problems, then PBL proposed individuals must be engaged in problems centered on job tasks or other real-life activities. This model extended the literature by explaining how individual differences within individuals mediate problem solving.

Gunawardena and Zittle (1997) contributed to the literature on social construction of knowledge with their work on Computer Mediated Conferencing (CMC) environments by demonstrating that social presence is a vital component of learning. They defined social presence as the degree to which an individual is perceived as a real person in CMC environments. The basic premise of their work is that both social presence and the sociocultural context of individuals must be taken into consideration to promote social construction of knowledge. Furthermore, Gunawardena and Zittle (1997) identified, through a stepwise regression analysis, that social presence is a significant factor in improving learner satisfaction. Their findings lent support to the thesis of scholars like Johansen et al. (1988), who had already identified that teleconferencing offered instructors and students a reliable telecommunications infrastructure and a virtual space to nurture social presence.

Looking to the future of education, the International Commission on Education for the Twenty-first Century (1998), chaired by Jacques Delors conducted a total of eight international hearings and surveyed 130 experts. Among its numerous groundbreaking findings, this commission reported to UNESCO the vital relevance of global interdependence, information societies and learning societies, and the uneven distribution of knowledge, all of which pointed to the lack of official adherence to social constructivist approaches to instruction, especially for younger generations. In addition, the commission identified four pillars of education: learning to know, learning to do, learning to live together,

and learning to be. The social pillar, learning to live together, was highlighted as the most needed to promote favorable conditions for effective learning, lending support to the need for students and educators, generally speaking, to engage in social construction of knowledge.

When Bransford, Brown, and Cocking (2000) took part of the Committee on Developments in the Science of Learning, they documented how the learning goals for schools had undergone major changes during the previous century. As a result, this committee explored the design of learning environments from different perspectives of human learning, particularly "the degree to which learning environments are learner centered, knowledge centered, assessment centered, and community centered" (p. 131). According to this committee the term Community Centered includes the classroom, the school, and the degree to which students, teachers, and administrators feel connected to the larger community of homes, businesses, states, the nation, and even to the world. Therefore, norms for people that are learning from one another and continually attempting to improve are especially important.

Similarly, Brown and Cole (2000) used the notion of Socially Shared Cognition in their effort to create and sustain model systems of educational activity. They explained that "on the one hand sharing refers to receiving, using, and experiencing in common with others. On the other hand, sharing also means to divide or distribute something between oneself and others" (p. 197). Also, they assumed that cognition is distributed among the participants, the artifacts they use, and the social organizations of collaboration.

Based upon a review of literature, McCombs and Vakili (2005) remarked that different perspectives usually demand negotiation that triggers creativity and innovation. They addressed this idea in their Learner-centered Framework for e-Learning. They built a

definition of Learner-centered instruction on top of fourteen principles that were categorized into four research-validated domains: Cognitive and Metacognitive Factors, Motivational and Affective Factors, Developmental and Social Factors, and Individual-differences Factors.

Thus, researchers around the world have been conducting a considerable number of studies to explore and analyze different approaches to the design of online courses, with a visible enthusiasm for social constructivism, a perspective that suggests a course is appropriate for the twenty first century if it offers high quality instruction based on diversity, student initiative and self-direction, collaboration, and integration of tools such as discussion boards that foster social construction of knowledge.

To reiterate, social construction of knowledge is a function of interaction, which is understood as a reciprocal influence among individuals that engage in dialogue. Therefore, central students may pave the way for knowledge construction by interacting with other students in social networks that emerge from online discussion forums.

All in all, Social Constructivism has influenced the design and development of online courses. It provides the impetus for a re-examination of the instructional design process itself and for the role of technology in online courses. Hence, social constructivist instructional design principles have emerged as theoretically sound approaches to building and facilitating online courses.

The Interaction Analysis Model

The Interaction Analysis model was created by Gunawardena et al. (1997) to examine knowledge construction in an online environment mediated by computer communication. The model's theoretical framework is based on social constructivist principles, so it considers knowledge construction as a function of interaction. The authors of this model put forward a

definition of interaction that considers "the entire gestalt formed by the online communications among the participants" (p. 407) and presented an analogy between knowledge construction and a patchwork quilt as an organized whole with many unique messages sewn together. This definition of interaction is different than other definitions in that it does not focus only on individual relations, but on the totality of interconnected relations that emerge from online communication, so the authors argue for considering an entire message/post as the unit of analysis.

Due to the predominance of discussion forums as a fundamental ingredient for knowledge construction over other types of learning activities in online courses, it is worth explaining the characteristics of the Interaction Analysis Model, shown in Table 1, which describes in detail five phases of knowledge co-construction, generally described as follows: Phase I) sharing, comparing, Phase II) dissonance, Phase III) negotiation, co-construction, Phase IV) testing tentative constructions, and Phase V) agreement, application of new knowledge.

Table 1

The Interaction Analysis Model by Gunawardena et al. (1997)

PHASE I: SHARING/COMPARING OF INFORMATION. Stage one operations include:	
A. A statement of observation or opinion	[PhI/A]
B. A statement of agreement from one or more other participants	[PhI/B]
C. Corroborating examples provided by one or more participants	[PhI/C]
D. Asking and answering questions to clarify details of statements	[PhI/D]
E. Definition, description, or identification of a problem	[PhI/E]
PHASE II: THE DISCOVERY AND EXPLORATION OF DISSONANCE OR INCONSISTENCY AMONG IDEAS, CONCEPTS OR STATEMENTS. (This is the operation at the group level of what Festinger [20] calls cognitive dissonance, defined as an inconsistency between a new observation and the learner's existing framework of knowledge and thinking skills.) Operations which occur at this stage include:	
A. Identifying and stating areas of disagreement	[PhII/A]
B. Asking and answering questions to clarify the source and extent of disagreement	[PhII/B]
C. Restating the participant's position, and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view	[PhII/C]
PHASE III: NEGOTIATION OF MEANING/CO-CONSTRUCTION OF KNOWLEDGE	
A. Negotiation or clarification of the meaning of terms	[PhIII/A]
B. Negotiation of the relative weight to be assigned to types of argument	[PhIII/B]
C. Identification of areas of agreement or overlap among conflicting concepts	[PhIII/C]
D. Proposal and negotiation of new statements embodying compromise, co-construction	[PhIII/D]
E. Proposal of integrating or accommodating metaphors or analogies	[PhIII/E]
PHASE IV: TESTING AND MODIFICATION OF PROPOSED SYNTHESIS OR CO-CONSTRUCTION	
A. Testing the proposed synthesis against "received fact" as shared by the participants and/or their culture	[PhIV/A]
B. Testing against existing cognitive schema	[PhIV/B]
C. Testing against personal experience	[PhIV/C]
D. Testing against formal data collected	[PhIV/D]
E. Testing against contradictory testimony in the literature	[PhIV/E]
PHASE V: AGREEMENT STATEMENT(S)/APPLICATIONS OF NEWLY-CONSTRUCTED MEANING	
A. Summarization of agreement(s)	[PhV/A]
B. Applications of new knowledge	[PhV/B]
C. Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction	[PhV/C]

In Learning Sciences, the Interaction Analysis Model by Gunawardena et al. (1997) is not to be confused with Jordan and Herderson's (1995) definition of Interaction Analysis as the examination of "interaction of human beings with each other and with objects in their environment. It investigates human activities, such as talk, nonverbal interaction, and the use of artifacts and technologies" (p. 39), because online interaction in the form of discussion forum posts is not talk (speech).

In the context of distance education, Moore (1989) suggested there are three categories of interaction, namely, learner-learner interaction, learner-content interaction, and learner-instructor interaction. Other scholars like Hillman, Willis, and Gunawardena (1994) identified a fourth type of interaction called learner-interface interaction, which is the result of individuals having to interact with high-tech devices to learn at a distance.

The Interaction Analysis Model by Gunawardena et al. (1997) emerged as a qualitative method to approach online interaction among individuals with regards to knowledge construction. This model was designed to assess social construction of knowledge by examining computer mediated communication transcripts. While the model does not specify whether it should only be applied to learner-learner or learner-instructor interaction, it does offer a technique to examine online communication, for instance from an debate or a discussion forum.

The Interaction Analysis Model probably became popular because of its simplicity and flexibility, which have helped several researchers (e.g., De Wever, Van Keer, Schellens and Valcke, 2007; Heo, Lim and Kim, 2010; Hou, Chang and Sung, 2008; Lopez, 2004; Sing and Khine, 2009) to determine occurrences of social construction of knowledge in online discussions, typically in educational settings. The model's analysis procedure consists of

reading every message from a discussion transcript and assigning them one or more codes for the purpose of identifying different phases of social construction of knowledge.

Gunawardena et al. (1997) narrated:

The researchers did not feel comfortable with arbitrarily designating a single posting as the unique unit of analysis, so occasionally a message that contained two or more distinct ideas or comments were coded in two or more phases. The messages were coded independently by both researchers. Discrepancies were discussed, and a single coding was determined from these discussions (p. 427).

Clearly, the aforementioned procedure differs from content analysis (Krippendorff, 2004), which uses mutually exclusive categorical variables that measure the existence and/or frequency of data from separate units of analysis without considering their relationship.

This flexibility has been appealing to many researchers who applied the model to transcripts of online discussion forums (e.g., Buraphadeja and Dawson, 2008; Chai and Tan, 2009; De Wever, Van Keer, Schellens, and Valcke, 2007; De Wever, Van Winckel, and Valcke, 2008; De Wever, Van Keer, Schellens, and Valcke, 2009; De Wever, Van Keer, Schellens, and Valcke, 2010; Heo, Lim, and Kim, 2010; Hou, Chang, and Sung, 2008; Hou, Chang, and Sung, 2009; Lopez, 2004; Paulus, 2007; Sing and Khine, 2009; Schellens, Van Keer, De Wever, and Valcke, 2007; Tan, Ching, and Hong, 2008). The common denominator of these studies was a need for researchers to identify the characteristics of online messages that contributed or lead to complex phases of social construction of knowledge in discussion forums.

For instance, Paulus (2007) relied on the Interaction Analysis Model to document how online communication contributed to the social maintenance of a group of students just

like Heo, Lim, and Kim (2010). Similarly, Schellens, Van Keer, De Wever, and Valcke (2007), as well as, De Wever, Van Keer, Schellens, and Valcke (2009, 2010) analyzed the impact of assigning and rotating roles among group members during the social negotiation phase in discussion forums. "It is worth noting that IAM explicitly attributes the success of the asynchronous discussion-based online learning and critical thinking to social constructivism" (Buraphadeja and Dawson, 2008, p. 139). To reiterate, Chai and Tan, (2009) stated "the IAM was selected because it is premised on a social constructivist theoretical foundation" that was consistent with their study.

Concerning emerging cultural factors involved in online interaction through discussion forums, Lopez (2004) attributed his finding of students making a leap from basic phases of social construction of knowledge to complex phases, without passing through intermediate phases to a lack of open disagreement. In his application of the Interaction Analysis Model, Lopez (2004) observed cognitive dissonance was not evident in his data as open disagreement with ideas expressed by others might not to be appropriate or at least not a necessary element in the Mexican sociocultural context.

Another cultural factor that provides "one explanation to the amount of student participation in group discussion forums is the learning culture of students" (De Wever, Van Winckel, and Valcke, 2008, p. 38). This explanation was advanced by Tan, Ching, and Hong (2008), who considered characteristics of participants such as membership to the same school cohort and professional background before arriving to a conclusion about the process of social construction of knowledge.

In short, the general direction researchers have taken with the Interaction Analysis Model has not been limited to discussion forums and some researchers have also applied it to

blogs and wikis, mostly in undergraduate courses and to a lesser degree in graduate courses, and a few professional development courses. In addition, the model's coding categories are simple—or generic—enough that they have been utilized to examine datasets from a myriad of disciplines and subjects, provided interaction took place online.

Social Network Analysis

SNA is a perspective grounded on the idea that social life is created primarily by relations and the patterns they form and it is best understood as a perspective within the social sciences and not as a method or narrowly defined theory, for social networks are formally defined as a set of network members that are tied by one or more types of relations (Wasserman and Faust, 1994). Along similar lines, Carrington and Scott (2011) state:

Unlike a theory, social network analysis provides a way of looking at a problem, but it does not predict what we will see. Social network analysis does not provide a set of premises from which hypotheses or predictions can be derived (p. 22).

Thus, the first place where a social network analyst looks at a problem is a social network, which is a set of network members or actors connected by one or more relations that can be categorized according to Borgatti, Mehra, Brass, and Labianca (2009) into four broad categories of relations: similarities, social relations, interactions, and flows. Similarities happen when two individuals share attributes such as demographic characteristics, attitudes, locations or group memberships. Social relations include kinship or other types of commonly defined role relations (e.g., friend, student). Interactions refer to behavior-based ties such as speaking with, helping, or inviting into one's home. Flows are relations based on exchanges or transfers between individuals and may include relations in which resources, information or influence flow through networks; like interactions flow-based relations often happen within

other social relations and researchers frequently assume or study their coexistence. For example, in online discussion forums an information flow may coexist with a social relation among students, resulting in social construction of knowledge.

The first use of the term Social Network is attributed to Barnes (1954), who is highly regarded in the field of anthropology, but other sociology and social psychology scholars also pioneered what is known today as SNA, for instance, the earliest work on SNA is considered to be that of Moreno (1934), Bavelas (1948), Newcomb (1953), and Cartwright (1977).

The knowledge base of SNA reached uniformity with the work of Wasserman and Faust (1994), who conducted an exhaustive investigation of the different methods and applications that SNA had been given up to that time. They provided solid ground to the interest and curiosity of the social and behavioral sciences community and suggested SNA was so appealing due to its focus on relationships or interactions among social entities (e.g., individuals, organizations, nations, companies, etc.) and their patterns. Moreover, SNA allows researchers to produce diagrams of social networks, which give them the ability to graph their structure as patterns of interaction.

Some of the principles that guide social network analysts are the principles of relations, and networks, which produce explanations of phenomena that do not assume environments, attributes or circumstances affect actors independently, thus analysts focus on relations not attributes, and on networks not groups. For instance, analysts maintain that causation is not located in the individual, but in the social structure, moreover they do not treat social network membership as uniform and they do not treat actors as belonging only to sets of mutually exclusive groups, *au contraire*, environments, attributes or circumstances

affect actors interdependently. Furthermore, analysts study patterns of relations within networks, not just relations between pairs (Carrington and Scott, 2011).

There are two ways in which social network analysts use the SNA perspective for theorizing and conducting research, they either study patterns of relations inductively or address important issues/phenomena through formalist or structuralist theories. While formalist theories, study the effects of different forms of social networks and the causes of these forms, structuralist theories study how patterns of relations can explain important topics (Carrington and Scott, 2011).

Structuralists use at least four different approaches to adopt a position that maintains relations matter. First, they can define key concepts in network terms. Second, they can test an existing theory by utilizing relation-based definitions of the theory, as opposed to attribute-based or group-based definitions, e.g., the GPA of a student may have an explanation beyond a strong correlation to the student's gender or athletic club membership, that is to say, the explanation could be in the real patterns of ties to people in the student's social network(s) who are willing to offer support. Third, structuralists can look at network causes of phenomena by asking what kinds of social networks lead to particular outcomes. Fourth, they can look at network effects of phenomena to study the causes of certain types of social networks and actor positions (Carrington and Scott, 2011).

There are four mechanisms social network analysts use to provide answers to research questions in terms of social networks, namely, transmission, adaptation, binding, and exclusion. Transmission refers to the idea of treating network relations as pipelines through which different things, such as information flow. Adaptation occurs when two individuals make the same choices because they have similar network positions. Binding happens when a

network binds together to act as one unit. Exclusion occurs when the presence of one relation prevents the existence of another (Carrington and Scott, 2011).

Operationalizing Social Networks

SNA is a perspective that offers researchers both a set of algorithms and analysis techniques, which allows them to develop specific ways to measure phenomena and analyze relation-based data. Relation-based data is paramount in the operationalization of social networks because it is not sound to rely only on analytical techniques that consider separate individuals as primary. Studying phenomena from a network perspective requires that at least one theoretically significant concept be defined relationally e.g., social construction of knowledge—a function of interaction—involves an information flow that coexists with a social relation among students.

Researchers who study phenomena from a network perspective think about what kinds of networks are caused by different activities, such as interaction, and vice versa, which requires mapping sociological concepts onto particular network forms. Thus, when the effect of networks on phenomena is studied, the results are sociologically significant. On the other hand, if something causes a network to be either be well-connected or fractured impacting the relation or interaction between actors, the connection or fracture matters because of the social effects it may have.

Social network analysts decide what kinds of networks and what kinds of relations they will study before collecting data. Carrington and Scott (2011), explain two kinds of networks from which analysts must choose before starting to delimit the boundaries of their studies, namely: whole vs ego networks, and one-mode vs two-mode networks. Whole networks take a bird's-eye view of social structure, focusing on all actors rather than any

particular one. These networks begin from a list of actors and include data on the presence or absence of relations between every pair of actors, for example, the network that emerges from students who interact in an online discussion forum. In contrast, ego networks focus on the network surrounding one actor, known as the ego.

Analysts use the whole networks approach, according to Freeman (1979), to explain characteristics of social networks such as density, the average path length necessary to connect pairs of nodes, the average tie strength, the extent to which the network is dominated by one central actor (centralization) or the extent to which the network is composed of similar nodes (homogeneity) or of nodes with particular characteristics (composition), such as the proportion of network members who are women.

Most of the time, researchers who examine whole networks collect data on a single type of actor in networks where every actor could conceivably be connected to any other actor, therefore most of the networks they examine are one-mode networks. In contrast, two-mode networks, also referred to as affiliation networks, involve relations based on co-membership. In addition, researchers have to choose how to measure relations after selecting the kinds of networks they want to study and defining a theoretically significant concept relationally, and this choice is between directed or undirected and binary or valued relations (Carrington and Scott, 2011). Directed relations go from one actor to another and may be reciprocated, while undirected relations exist between actors in no particular direction. Both directed and undirected relations can be measured as binary relations that either exist or not within each pair of actors, or as valued relations that can be stronger or weaker.

Centrality

In SNA there is a group of metrics known as centrality measures, which quantify the relevance or influence of an individual in a social network based on her relations with other individuals. According to Wasserman and Faust (1994) central individuals or "actors are those that are extensively involved in relationships with other actors. This involvement makes them more visible to the others" (p. 173), thus what is appealing for researchers studying interaction in online discussion forums is the relationship of students with high centrality and social construction of knowledge.

With regards to social relations in online discussion forums, the question of who writes to who has important implications for information flow, so it is relevant to analyze interaction patterns of both independent relations and the totality of interconnected relations. Thus, student centrality is a concept that accounts for the social aspect of knowledge construction in that it serves as an indicator of student influence on other students. As the researcher explained in his problem statement, the centrality of different individuals in a social network that emerges from a discussion forum can be analyzed with centrality measures and social network diagrams that depict interaction patterns.

From the SNA perspective, actors (also known as nodes) and their actions are viewed as interdependent rather than independent autonomous units, so the actors in this study will be students. Second, relational ties (linkages also known as arcs or edges) between students are interaction channels for transfer or "flow" of information through posts in discussion forums. Third, social network diagrams can represent patterns of interaction among students. Fourth, each student interacts with other students, each of whom interacts with a few, some,

or many others, and so on. Therefore, the concept of social network refers to the finite set of students and their interactions in one discussion forum.

While centrality measures quantify the relevance or influence of an individual in a social network, there is a holistic measure of a social network that takes into consideration the totality of interactions named density, which Faust (2006) defines as "density, d , of a network" is the number of ties (interactions) in the network divided by the possible by number of ties (interactions) as illustrated by the following formula:

$$d = \text{actual ties (interactions)} / \text{maximum possible ties (interactions)}$$

thus, a well-connected social network—with high density—is one where everybody interacts with everybody else, enabling the flow of information in the presence of key students with high centrality (more influential), also known as "information brokers."

Social network diagrams provide visual representations of interaction in discussion forums that would otherwise be hidden to researchers, online instructors and students, instructional designers, and university leaders as demonstrated by some researchers (e.g., Dawson et al., 2011; Haythornthwaite, and De Laat, 2010; Firdausiah, and Yusof, 2013; and Toikkanen, and Lipponen, 2011) who have used SNA to produce social network diagrams as a way of mapping interaction patterns of online discussion forums to illustrate social construction of knowledge.

Online Interaction and Social Network Analysis

There have been some research efforts to study interaction in online discussion forums, as it relates to both construction of knowledge and student centrality, from both a quantitative and qualitative perspective because textual data does not seem to be enough to explain the discussion process in a more visual manner and vice versa. For example, in

studies where quantitative results were limited, several researchers (e.g., Aviv, Erlich, Ravid, and Geva, 2003; Buraphadeja, 2010; Dawson, 2008; Mazza and Dimitrova, 2004; Shea, Hayes, Vickers, Gozza-Cohen, Uzuner, Mehta, Valchova, and Rangan, 2010; Tirado, Hernando, and Aguaded, 2011; and Li, 2009) conducted mixed methods research to carry out supplemental analyses that explained social construction of knowledge and student centrality.

Generally speaking, the aforementioned studies fall into the field of educational data mining and/or learning analytics, as classified by Johnson et al. (2012), which is a field that relies heavily on digital data extracted from LMSs and the application of computer programs to conduct SNA at speeds that were unthinkable at the beginning of the last century. For example, Aviv, Erlich, Ravid, and Geva (2003) examined transcripts of online discussion forums generated by 19 students in a distance education university and ran an SNA computer program. They found that highly orchestrated (structured) interaction is associated with a high degree of social cohesion, and noted that too cohesive a group could stifle criticism and, therefore, open disagreement.

A study found that diagrams of interaction in discussions help instructors quickly and more accurately grasp information about social, cognitive, and behavioral aspects of students such as isolation, lack of attendance and alignment of discussions with learning objectives, as reported by Mazza and Dimitrova (2004), who had six instructors evaluate a computer program focusing on effectiveness, efficiency, and usefulness. This computer program produced diagrams of interaction in discussions, matrices of student performance on quizzes, and graphs of student behavior (e.g., access to content pages by topic, global hits to the course, progress with the course schedule, and number of messages).

In another research project, Dawson (2008) studied discussion forums in 25 online courses using an SNA computer program, analysis of discussion transcripts, and an online survey to collect data relating to sense of community. In addition, they conducted an audit for further clarification of the results using a case study approach and statistical analyses. "The findings suggest that the position an individual occupies in the social network is indicative of both their degree of perceived sense of community and the nature of the academic and social support the individual requires" (p. 236). Qualitative analyses suggest that additional socialization activities are needed to speed up the formation of social relationships and enhance the overall strength of social ties. It was indicated that further research is required to study the relationship between student social networks and other dimensions influencing the learning environment.

Another study revealed a random change in interaction patterns over time, as reported by Li (2009), who examined 204 discussion posts from an undergraduate course combining content analysis and SNA to explore how student roles—defined by SNA centrality measures—are related to student discourse in terms of social construction of knowledge. Buraphadeja (2010) conducted a similar study to examine discussion transcripts generated by 189 graduate students looking for occurrences of social construction of knowledge and producing diagrams of interaction between students, but reported no statistically significant correlation between the results of content analysis and SNA. The researcher highlighted "the absence of a [co] relationship was found under conditions where discussion was an activity designed for individual responses rather than interaction among participants" (p. 131).

Shea, Hayes, Vickers, Gozza-Cohen, Uzuner, Mehta, Valchova, and Rangan (2010) found that measures of social presence derived through content analysis align well with

measures of density as defined by SNA. This team of researchers coded 944 discussion posts for teaching presence, social presence, and cognitive presence, and conducted SNA for visual and statistical analyses of interaction.

Tirado, Hernando, and Aguaded (2011) examined discussion posts generated by 16 students from an associate's degree in a Spanish online university, drawing on previous models of content and/or interaction analysis they created a new model to analyze interaction and also used an SNA computer program to produced social network diagrams. They found similar results than Li (2009), who identified there was a random change in both student discourse and student centrality over time. On the other hand, they found an inversely proportional relationship between the size of discussion groups and density of social networks, which is the quintessential SNA measure that explains how well connected participants are in a discussion. According to Hernando, and Aguaded (2011), further research should focus on data generated in the context of collaborative instructional design, particularly in the possibility of a positive effect of high density on interaction between students in large groups.

Wise, Speer, Marbouti, and Hsiao (2013), examined interaction in a blended course by conducting a mixed methods study that combined statistical cluster analysis to identify interaction patterns in discussions, and case studies (follow up of one participant from each cluster) to make sense of the way these interactions play out in action. Results indicated student behaviors such as scanning around half of the posts viewed, as opposed to reading them thoroughly, accounted for the vast majority of time students spent in the discussions, so it was recommended to focus further research on the motivations behind these scanning behaviors and the relationship to learning in the discussions.

Taking into consideration the studies above, the main advantage of a mixed methods approach seems to be the ability for researchers to supplement their analysis with two or more perspectives, as opposed to being restricted to analysis techniques typically associated with qualitative research or quantitative research, as stated by Creswell and Clark (2007):

Mixed methods research encourages the use of multiple worldviews or paradigms rather than the typical association of certain paradigms for quantitative researchers and others for qualitative researchers. It also encourages us to think about a paradigm that might encompass all of the quantitative and qualitative research, such as pragmatism, or using multiple paradigms in research (p. 10).

Thus, researchers have turned to mixed methods research because quantitative methods are limited in their understanding of the context in which people interact and the personal biases and interpretations of quantitative researchers are rarely discussed. On the other hand, qualitative research is perceived as deficient because of the personal interpretations made by the researcher, the bias created by this, and the difficulty in generalizing findings to a large group because of the limited number of participants studied.

It is worth summarizing the epistemological differences and similarities between the Interaction Analysis Model and SNA. While the Interaction Analysis Model offers researchers a qualitative research technique that is subjective by nature to examine interaction in online environments (mediated by computer communication), SNA offers researchers different quantitative research techniques that are objective by nature to examine interaction in a variety of environments. Furthermore, the Interaction Analysis Model is an abstract way of outlining the process of social construction of knowledge and it is rooted in a theoretical framework based on social constructivism, on the other hand, SNA is a

perspective rooted in sociology and social psychology, both of which focus on relationships or interactions among social entities and their patterns.

In addition, while researchers who use the Interaction Analysis Model argue for a complete post as the unit of analysis, social network analysts have developed unique techniques to analyze relation-based data, so they take an individual as the unit of analysis in conjunction with the post because even though an individual or a post can be fundamental units of analysis separately, in SNA they are not primary on their own because it is not theoretically sound to rely on separate units from this perspective, which requires researchers to operationalize concepts relationally.

To reiterate, the unit of analysis in SNA is also the post, but in connection to the student interaction, which occurs between members of the social network as demonstrated by De Laat, Lally, Lipponen, and Simons (2007). It is worth highlighting the fact interaction itself is the overlap between the Interaction Analysis Model and SNA that allowed the researcher to mix the two approaches because even though the attributes of these messages (e.g., the author, the message content) are primary to the first approach, they are secondary to SNA, but from a mixed methods perspective these attributes are key to the interpretation of the interaction patterns that will be revealed by SNA.

The Interaction Analysis Model and SNA are similar in that both perspectives can be used to explain interaction and consider it equally relevant to analyze interaction patterns of independent relations as well as the totality of interconnected relations among social entities. Interaction will be key in this study, because social construction of knowledge as defined by Gunawardena et al. (1997) is a function of online interaction, which involves phases such as sharing/comparing of information, dissonance, negotiation/ co-construction of knowledge,

testing tentative constructions of knowledge, and agreement/application of new knowledge, all of which require an information flow that coexists with a social relation among students.

Therefore, the researcher was able to provide a more complete explanation of social construction of knowledge by mixing methods in the sense that SNA supplements the Interaction Analysis Model by accounting for the social aspect of knowledge construction with evidence of the basic generation of knowledge arising in and out of interaction within social networks of students that emerge from online discussion forums.

CHAPTER THREE: METHODOLOGY

The researcher studied a dataset of three archived non-structured discussion forums from an online graduate course, which had a social constructivist instructional approach, meaning they were initiated by students and only had student-to-student interaction, i.e., they were open ended and student-centered.

The researcher used sequential mixed methods as a strategy of inquiry because it allowed the researcher to expand on the findings of one method with another method. The first stage involved the Interaction Analysis Model, the second SNA, and the third a combination of both. Accordingly, the researcher employed both open and closed ended research questions at different stages of the analysis. The rationale behind this mixed methods research design is based on the idea that each method allowed the researcher to examine patterns of the totality of interconnected relations, not just relations between pairs, which implies that while relations are measured as existing between pairs of actors, explaining the effect and meaning of a tie between two actors requires taking into account the broader patterns of connections within the social network that emerges from one discussion forum (Barnes, 1972). This rationale goes hand in hand with Gunawardena et al's (1997) definition of interaction, which considers the entire gestalt formed by online communications.

In a nutshell, this approach gave the researcher the opportunity to produce more complete evidence of social construction of knowledge than either method alone, for this approach offers strengths that offset the weaknesses of applying just one method to a web-based secondary dataset of discussion forums, as suggested by Creswell and Clark (2007). For example, SNA supplements such an abstract technique as the Interaction Analysis Model

in the sense it can be used to produce diagrams of interaction patterns, which reveal both the information flow among actors as well as the type of social construction of knowledge phase that a post/reply carries.

Research Question

1. How does social construction of knowledge relate to student centrality as defined by SNA in Spanish online discussion forums conducted in Mexico?

1a. Does knowledge construction occur through student-to-student interaction in online discussion forums as measured by the IAM?

1b. What are the characteristics of the social network created by students in an online discussion forum?

1c. What are the characteristics of posts published by students with high centrality?

1d. Does higher student centrality contribute to a higher level of social construction of knowledge?

Research Design

The researcher relied on a sequential mixed methods study to examine interaction patterns of graduate students who participated in three non-structured (open-ended) discussion forums, which were part of an online course on web conferencing in a learning technologies master's degree at a Mexican university. In the first stage of the analysis he applied the Interaction Analysis Model to transcripts of discussion forums to find occurrences of social construction of knowledge by identifying qualitative characteristics of posts published by students. Next, the researcher obtained some centrality measures such as number of posts, in-degree, out-degree, and betweenness to derive the degree of student centrality using SNA. Then, he compared and contrasted results from both methods,

highlighting occurrences of social construction of knowledge of students with high centrality, in an effort to explain social construction of knowledge and social networks.

Participants

The researcher looked at a web-based secondary dataset of three non-structured (open-ended) online discussion forums that contained de-identified authors, title, date, time, and posts extracted from a graduate course on web conferencing, which was part of a master's in learning technologies in a large Mexican public university. Twenty-one graduate students between the age of 23 and 65 generated the dataset and gender was equally represented. The discussion forums he examined were deployed through the Moodle LMS,

The first discussion forum ran at the beginning of Spring 2015, the second around the midterm, and the third by the end of the term. These forums were part of a graduate online course on web conferencing in Spanish at a large public university in western Mexico. These three forums were archived when the semester concluded in the university's Moodle LMS.

The main inclusion criterion for this study was graduate students should have participated in discussion forums of the selected online course. There was no sensitive information to be removed from any discussion transcript that could have compromised the identity of a student.

Due to the modular structure of the online course students were expected to study the content and participate in learning activities frequently as they had deadlines, but student-to-student interaction occurred primarily as voluntary participation in discussion forums. At the beginning of the online course, students were studying factual information that introduced them to the subject, then as the course progressed gradually towards more analytical learning activities students were expected to engage in thought provoking discussions, and by the end

of the course students worked in small groups preparing to host an educational web conference as a final project.

The instructor asked students to make an initial post and reply to at least two of their classmates, and allowed them to create forums in order to initiate a discussion. Three different students initiated the three forums the researcher examined in this study. Students addressed the following topics in their prompt: Forum 1) Evaluating web conferencing effectiveness, Forum 2) Technical Support, and Forum 3) Pros and cons of web conferencing.

Unit of Analysis

The identification of the unit of analysis had to be reliable and encompass the phenomenon under study, so accordingly with Gunawardena et al. (1997), the researcher chose the post as the unit of analysis because it is objectively identifiable, meaning multiple coders can agree consistently on the total number of units; it produces a clearly delimited set of observations; and it has parameters determined by the author of the post. This choice addressed the lack of uniformity in the choice of the unit of analysis and inadequacies in reliability found in the literature. In addition, by concentrating on the post as the unit of analysis it was possible for the researcher to report the intercoder reliability level in a straightforward fashion because coders did not need to argue about what a post is, as it is clearly defined by its author. Furthermore, the Interaction Analysis Model argues for a complete post as a unit of analysis.

In the application of the Interaction Analysis Model to examine transcripts of discussions, a post is taken as the unit of analysis and coded for as many occurrences or phases of social construction of knowledge as it contains, as opposed to mutually exclusive

categories utilized in content analysis. When conducting SNA, the researcher considered a student in conjunction with the post as the unit of analysis, student because this perspective requires a relational concept such as the concept of interaction. Thus, the student in conjunction with the post become an actor (node) that may be connected to other students who interacted with each other in a discussion forum.

As suggested by Rourke, Anderson, Garrison, and Archer (2001), the researcher treated one post as the unit of analysis because a post is an objective unit and is considered as the unit defined by the original author. In other words, a post is objectively identifiable in the sense multiple coders that examine transcripts can agree consistently on the total number of units because a post is clearly delimited by its own boundaries within an online discussion forum.

On the hand, in the application of social network analysis, the researcher needed use a

Data Collection

The Interaction Analysis Model required discussion forum transcripts be extracted from a web-based secondary dataset archived in Moodle and exported both as PDF files and web archives, which offer great readability to human coders working with PDF readers or web browsers. Also, PDF files and web archives allow human coders to keep color highlights, annotations, and comments, keeping data safe in password protected computers with encrypted hard/flash drives. For example, posts were copied from said PDF files or web archives and pasted on a coding spreadsheet in order to have the text in the first column and then code with 1 or 0, as a way to improve precision.

SNA required network data, which had to be derived from the coding spreadsheets of the three discussion forums and processed using Microsoft Excel with NodeXL, a SNA plug-

in (Hansen, Shneiderman, & Smith, 2010), which allowed the researcher to enter posts as actors (nodes) with the actor labels being pseudonyms of students, and graph interaction(s) as edges or arcs. For example, if student A replies to student B, a directed edge (depicted as an arrow) was graphed from A to B. Directed edges were added with labels containing posting sequence number as well as the Interaction Analysis Phase of the post. NodeXL was also used to calculate the centrality measures and produce a social network diagram of interaction patterns. In the context of discussion forums, it is valuable to look at social network diagrams that show different interaction patterns and reveal student centrality. The preliminary step to generate these diagrams was to obtain the centrality measures of each student that published a post or replied to another student.

Data Analysis

This sequential mixed methods design aimed at analyzing social construction of knowledge and social networks. Table 2 shows the data analysis process through which interaction and social network analyses were conducted in stage 1 to determine occurrences of social construction of knowledge and student centrality respectively. In stage 2, the researcher compared and contrasted results from stage 1, which involved the use of diagrams of interaction patterns in discussion forums that illustrate the centrality of different students. Then, to explain the characteristics of the posts published by students with high centrality, he took post excerpts as textual evidence to complete the mixed methods design.

Table 2

Data Analysis Process

Stage 1. Separate IAM and SNA analyses	IAM data analysis:	SNA data analysis:
Stage 2. Data Comparison	<ul style="list-style-type: none"> • Prepare transcripts • Explore transcripts • Code transcripts • Produce results 	<ul style="list-style-type: none"> • Explore discussion forums • Get network data • Obtain centrality measures

Procedures for data analysis are presented in Table 3, which highlights the necessary sequence to mix the Interaction Analysis Model and SNA. The procedures for data analysis in Table 3 address each research question.

Table 3

Data Analysis Procedures

Research Question	Data	Procedure	Instrument
1. How does social construction of knowledge relate to student centrality as defined by SNA in Spanish online discussion forums conducted in Mexico?	Transcripts Network data	Compare and contrast IAM and SNA	IAM and SNA comparison table SNA diagrams
1a. Does knowledge construction occur through student-to-student interaction in online discussion forums as measured by the IAM?	Transcripts	IAM	IAM coding spreadsheet
1b. What are the characteristics of the social network created by students in online discussion forums?	Network data	SNA	SNA centrality measures table
1c. What are the characteristics of posts published by students with high centrality?	Transcripts Network data	IAM & SNA	IAM coding sheet & SNA centrality measures table
1d. Does higher student centrality contribute to a higher level of social construction of knowledge?	Transcripts Network data	IAM & SNA	IAM coding sheet & SNA centrality measures table

Interaction Analysis Model

Sampling Procedure. The researcher relied on purposeful sampling to select cases associated to the phenomenon under study and he used a strategy known as typical case, which aims at highlighting what is typical, normal or average. The objective of this strategy was to describe what is typical to those unfamiliar with the setting, not to make generalizations about the experiences of all participants (Patton, 2002). In the implementation of mixed methods, the rationale behind purposeful sampling for qualitative data collection and analysis is, for the sake of redundancy, to purposefully select participants that would help the researcher provide an explanation to the research problem and it does not require random sampling or selecting a large number of participants, as typically found in quantitative studies.

Analysis. Each unit of analysis was coded according to the Interaction Analysis Model by two research assistants, who were graduate students whose first language was Spanish and had taken a qualitative research graduate course. The researcher established intercoder reliability by training coders. Training included an orientation meeting and three subsequent meetings to explain the model and coding process using an Excel spreadsheet with a coding template and guidelines. In addition, coders were given sample discussion forum transcripts with examples and non-examples to practice. Meetings with coders included demonstrations of the coding model and discussions to reach a mutual agreement about the coding category to be selected. Quality control of the coding relied on the calculation of the intercoder reliability, which was calculated with the Percent Agreement statistic (Holsti, 1969) for all three forums.

Each post in the transcripts was coded/assigned a phase from Gunawardena et al.'s (1997) Interaction Analysis Model, which, defines the process of knowledge co-construction

in five phases generally described as follows: Phase I) sharing, comparing, Phase II) dissonance, Phase III) negotiation, co-construction, Phase IV) testing tentative constructions, and Phase V) agreement, application of new knowledge.

Based on the Interaction Analysis Model presented in Table 1 the researcher created a coding spreadsheet in Spanish to assign phases of social construction of knowledge to each post as shown in Figure 2.

UNIDAD DE ANÁLISIS: 1 POST = 1 UNIDAD					Fase 1	Fase 2	Fase 3	Fase 4	Fase 5	
TEMA	AUTOR	FECHA DD/MM/AAAA	HORA (24HRS)	RAMA (1.1.1)	COMPARTIR Y COMPARAR INFORMACIÓN	DESCUBRIMIENTO Y EXPLORACIÓN DE DISONANCIA O INCONSISTENCIA ENTRE IDEAS, CONCEPTOS O DECLARACIONES	NEGOCIACIÓN DEL SIGNIFICADO / CO-CONSTRUCCIÓN DEL CONOCIMIENTO	PROBAR --Y LA MODIFICACIÓN DE-- UNA SÍNTESIS PROPUESTA O CO- CONSTRUCCIÓN	DECLARACIÓN(ES) / APLICACIONES DEL SIGNIFICADO RECIÉN CONSTRUIDO	OBSERVACIONES
TEMA	Pseudónimo	31/12/2014	24:00	1	# + Categoría	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	

Figure 2. Interaction Analysis Model Coding Spreadsheet in Spanish

For didactic purposes, the researcher also created an English version of the aforementioned coding spreadsheet as shown in Figure 3.

UNIT OF ANALYSIS: 1 POST = 1 UNIT					Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	
POST	AUTHOR	DATE DD/MM/YYYY	TIME (24HRS)	BRANCH (1.1.1)	SHARING/COMPARING OF INFORMATION	THE DISCOVERY AND EXPLORATION OF DISSONANCE OR INCONSISTENCY AMONG IDEAS, CONCEPTS OR STATEMENTS	NEGOTIATION OF MEANING/CO-CONSTRUCTION OF KNOWLEDGE	TESTING AND MODIFICATION OF PROPOSED SYNTHESIS OR CO-CONSTRUCTION TESTING AND MODIFICATION OF PROPOSED SYNTHESIS OR CO-CONSTRUCTION	AGREEMENT STATEMENT(S)/ APPLICATIONS OF NEWLY-CONSTRUCTED MEANING	OBSERVATIONS
MESSAGE	Pseudonym	31/12/2014	24:00	1	#	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	
					0	0	0	0	0	

Figure 3 Interaction Analysis Model Coding Spreadsheet in English

Correspondingly, in Figure 4 the researcher translated to Spanish the descriptors of each specific phase previously shown previously in Table 1, or as the model refers to them, the operations in a post that signal the coder the occurrence of social construction of knowledge at different levels.

Fase 1	Fase 2	Fase 3	Fase 4	Fase 5
COMPARTIR Y COMPARAR INFORMACIÓN	DESCUBRIMIENTO Y EXPLORACIÓN DE DISONANCIA O INCONSISTENCIA ENTRE IDEAS, CONCEPTOS O DECLARACIONES	NEGOCIACIÓN DEL SIGNIFICADO / CO-CONSTRUCCIÓN DEL CONOCIMIENTO	PROBAR --Y LA MODIFICACIÓN DE-- UNA SÍNTESIS PROPUESTA O CO-CONSTRUCCIÓN	DECLARACIÓN(ES) / APLICACIONES DEL SIGNIFICADO RECIÉN CONSTRUIDO
A. Una declaración de observación u opinión. B. Una declaración de acuerdo de uno o más participantes. C. Corroborar ejemplos proporcionados por uno o más participantes. D. Preguntar y responder cuestiones para aclarar detalles de las declaraciones. E. Definición, descripción o identificación de un problema.	A. Identificar y declarar áreas de desacuerdo. B. Preguntar y responder cuestiones para aclarar la fuente y el grado del desacuerdo. C. Reafirmar la posición del participante y posiblemente presentar argumentos o consideraciones que la soporten a través de referencias a la experiencia, erudición, información formal recolectada, o propuesta de una metáfora relevante o analogía del participante para ilustrar el punto de vista.	A. Negociación o aclaración de términos. B. Negociación del peso relativo que se le asignará a los tipos de argumento. C. Identificación de las áreas de acuerdo o superposición entre conceptos contradictorios. D. Propuesta y negociación de nuevas declaraciones que contengan acuerdo mutuo, co-construcción. E. Propuesta de metáforas o analogías de integración o complacientes.	A. Probar síntesis propuesta contra "el hecho recibido" como [éste] se compartió por los participantes o por su cultura. B. Probar contra el esquema cognitivo. C. Probar contra la experiencia personal. D. Probar contra la información recolectada. E. Probar contra testimonio contradictorio en la literatura.	A. Resumen de acuerdo(s). B. Aplicación del conocimiento nuevo. C. Declaraciones metacognitivas de parte de los participantes, ilustrando su entendimiento de que su conocimiento o forma de pensar (esquema cognitivo) ha cambiado como resultado de la interacción de la plática.

Figure 4. Interaction Analysis Model in Spanish

Again, two coders whose first language was Spanish analyzed the transcripts. Coders were graduate students who had completed a graduate level course in qualitative research in the field of social sciences. The intercoder reliability of the Interaction Analysis Model was established by reporting Holsti's (1969) percentage of agreement, for which at least two coders are needed. It was important to report this reliability level because Lucas, Gunawardena, and Moreira (2014) reported that "more than a half of the [Interaction Analysis Model] studies do not refer the type of reliability adopted." Generally speaking, reporting the reliability level contributes to the transparency of the coding process and the validity and replicability of the research.

When two coders use this type of model to code it becomes necessary to report the intercoder reliability level, which can be calculated using the percentage of agreement or Holsti's method (1969). In general, a Holsti's Percent Agreement higher than 90% or 0.90 is considered to be a high level of intercoder reliability and a percent agreement lower than 80% or 0.80 is considered to be a low level (Mao, 2017).

This level of intercoder reliability as defined by Holsti's (1969) Percent Agreement statistic uses the following formula: $PA_0 = \frac{2A}{(n_1+n_2)}$ where PA₀ is the proportion of agreement observed, A is the number of agreements between two coders, and n is the total number of items coded by both coders, or n₁, n₂ are the respective number of items coded by each of two coders. In a nutshell, the aforementioned equation is calculating reliability as agreements divided by the sum of agreements plus disagreements.

Other intercoder reliability statistics, typically used in content analysis are incompatible with this model because they are meant for quantitative analysis of random samples. Trying to impose intercoder reliability statistics such as Krippendorff's alpha, Cohen or Fleiss' kappa on results from coding spreadsheets like the one presented in Figure 2 is illogic because they require mutually exclusive codes/categories, which is not the case of the Interaction Analysis Model, in which the unit of analysis is coded for as many occurrences or phases of social construction of knowledge as it contains, therefore a post can be assigned every single code.

An example of such coding spreadsheet is given in Figure 5, which highlights in yellow posts published by students/authors (autor in Spanish) S1, S4, and S12. The analysis reveals that student S1's post was assigned Phase I (Fase 1) by both coders (codificador 1 and 2) and it was identified as post 0 (rama 0), which initiated the discussion. S4 was assigned

Phases I and II by both coders, but assigned Phases III and IV only by codificador 1, hence the need to calculate and report intercoder reliability. S12 was assigned Phases I and II by both coders, but coded for Phase III only by codificador 2 and Phase IV only by codificador 2.

UNIDAD DE ANÁLISIS: 1 POST = 1 UNIDAD					Fase 1		Fase 2		Fase 3		Fase 4		Fase 5		
TEMA	AUTOR	FECHA DD/MM/AAAA	HORA (24HRS)	RAMA (1.1.1)	COMPARTIR Y COMPARAR INFORMACIÓN	DESCUBRIMIENTO Y EXPLORACIÓN DE DISONANCIA O INCONSISTENCIA ENTRE IDEAS, CONCEPTOS O DECLARACIONES	NEGOCIACIÓN DEL SIGNIFICADO / CO-CONSTRUCCIÓN DEL CONOCIMIENTO	PROBAR --Y LA MODIFICACIÓN DE-- UNA SÍNTESIS PROPUESTA O CO- CONSTRUCCIÓN	DECLARACIÓN(ES) / APLICACIONES DEL SIGNIFICADO RECÉN CONSTRUIDO						
					Codificador 1	Codificador 2	Codificador 1	Codificador 2	Codificador 1	Codificador 2	Codificador 1	Codificador 2	Codificador 1	Codificador 2	
Tema 1	S1	05/12/2014	13:05	0	1	1									
	S2	06/12/2014	09:46	1	1	1	1	1	1	0	1	1	0	0	
	S3	07/12/2014	13:30	1.1	1	1	1	1	1	0	1	1	0	0	
	S4	07/12/2014	21:52	1.1.1	1	1	1	1	1	0	1	0	0	0	
	S5	07/12/2014	22:11	2	1	1	1	1	1	0	1	1	1	0	
	S6	08/12/2014	12:26	3	1	1	1	1	1	1	1	0	0	0	
	S7	09/12/2014	13:57	4	1	1	0	1	0	1	0	1	0	0	
	S8	11/12/2014	19:09	5	1	1	0	1	1	1	0	1	0	0	
	S9	11/12/2014	21:02	5.1	1	1	1	1	1	0	1	1	0	0	
	S10	19/12/2014	21:31	6	1	1	0	1	0	1	0	0	0	0	
	S11	20/12/2014	12:11	7	1	1	0	1	0	1	1	1	0	0	
	S12	21/12/2014	13:45	8	1	1	1	1	0	1	1	0	0	0	
	S2	21/12/2014	14:41	9	1	1	0	1	0	1	1	1	0	0	
	S13	21/12/2014	15:52	10	1	1	0	1	0	1	1	1	0	0	
	S14	22/12/2014	08:54	10.1	1	1	1	0	0	1	1	1	0	0	
	S15	22/12/2014	09:28	11	1	1	0	1	1	1	1	1	0	1	

Figure 5. Example of Interaction Analysis Model Coding Spreadsheet in Spanish

In this example, according to Holsti's method, there was an overall 70.21 percentage of agreement between the two coders, which was calculated using the equation $\text{Percent Agreement} = \frac{2A}{(n1 + n2)}$, where PA is the proportion of agreement observed, A is the number of agreements between two coders, and n1 is the total number of items coded by the first coder and n2 is the number coded by the second coder. The aforementioned equation calculates reliability as agreements divided by the sum of agreements plus disagreements.

Figure 6 shows an example of typical Interaction Analysis Model results organized by phases. In this example Heo, Lim, and Kim (2010), provide excerpts to show the characteristics of different posts, which in turn can be connected to students with different centrality.

Code	Phase	Indicator (examples only)	Raw data (examples only)
P1	Sharing and comparing of information	Presenting new information to team members	"I uploaded the first version of the analysis framework. Please give some feedback, and add your opinions"
P2	The discovery and exploration of dissonance or inconsistency among ideas, concepts or statements	Asking and answering questions to clarify the source	"Do we need to focus on the motivation theory for the analysis framework?"
P3	Negotiation of meaning/ Co-construction of knowledge	Negotiating the meaning of terms	"Well, I think no. 1 criteria will be merged with no. 4. What you think of?" (n/a)
P4	Testing and modification of proposed synthesis or co-construction	Testing against personal experience	
P5	Agreement statement/applications of newly-constructed meaning	Accepting and applying new idea	"Ok. I will accept and revise according to your comments"

Figure 6. Example of Interaction Analysis Model Results.

Social Network Analysis

Sampling Procedure. SNA will rely on the same exact cases obtained through purposeful sampling already described under the Interaction Analysis Model section in the methodology chapter, but there will be a slight difference in the type of data that will be analyzed. This type of data is known in SNA as network data, it is relational in nature and involves taking into consideration a student in conjunction with the post because together they become an actor (node) as explained earlier under the definition of the unit of analysis.

Analysis. As explained earlier in the literature review section relation-based data is paramount in the operationalization of social networks because it is not sound to rely only on analytical techniques that consider separate individuals as primary. Studying phenomena from the SNA perspective requires that at least one theoretically significant concept be defined relationally e.g., social construction of knowledge—a function of interaction—involves an information flow that coexists with a social relation among students.

The way in which the researcher used the SNA perspective to develop an explanation of social construction of knowledge and social networks in online discussion forums was through a structuralist view of the phenomenon, as explained earlier in the literature review of SNA. From this view, he took a look at network effects of the phenomenon in question by focusing his attention on the idea of transmission. To reiterate, transmission is one of the conceptual mechanisms, accordingly to Carrington and Scott (2011), network analysts use to explain their findings, thus the researcher paid special attention to the kinds of networks that were more likely to result in the most widespread information flow, the network positions most likely to receive them, and the ways in which different network structures create different patterns of information flow under different circumstances.

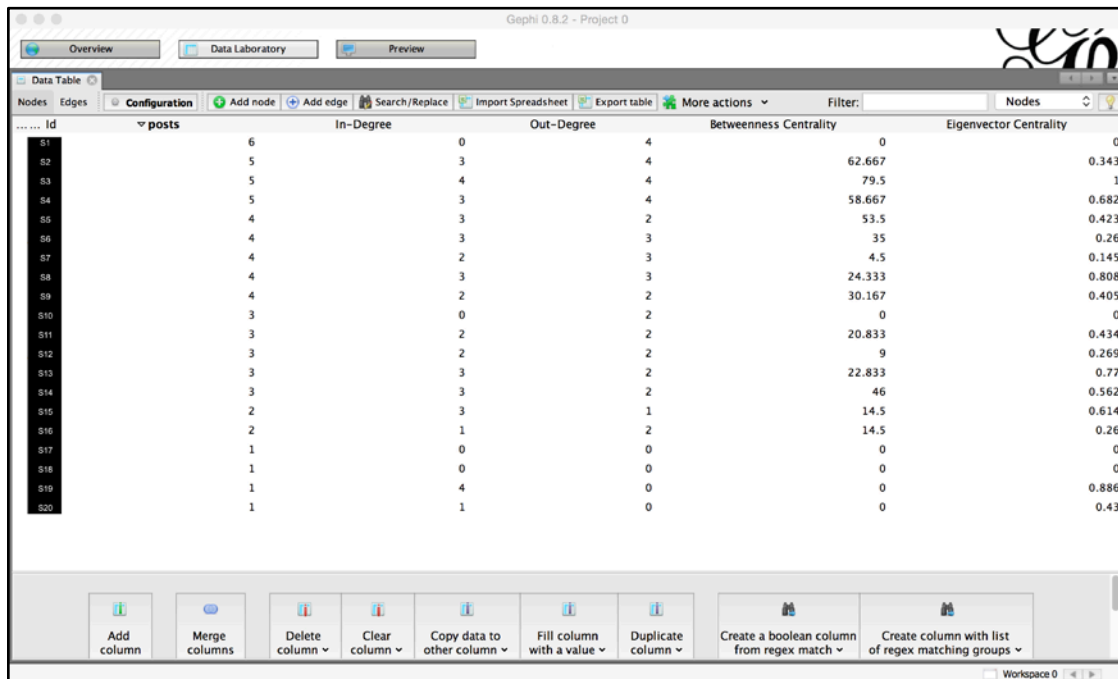
Furthermore, when collecting network data, the researcher focused on whole networks, as opposed to ego networks, and on one-mode data, as opposed to two-mode data, and last but not least he focused on directed ties measured as valued ties that can be stronger or weaker or transmit more or less information, or have more or less frequent contact.

Quality control of SNA relied on the utilization of four different centrality measures that were used to calculate student overall network centrality in three different discussion forums, namely: number of posts, in-degree, out-degree, and betweenness, all of which are defined below.

Centrality Measures. Number of posts is self-explanatory. In-degree, out-degree, and betweenness account for student overall degree of centrality. Generally speaking, centrality results from the number of interactions that each student has in a social network (Otte and Rousseau, 2002) that emerges from a discussion forum. More specifically, the in-degree measure counts inbound posts with other students while out-degree counts outbound posts. These measures, when considered separately, are indicators of network "prestige" (in-degree) so to speak, and influence (out-degree). As demonstrated by De Laat et al. (2007), in online discussion forums, "prestige" results from the number of replies directed to a student's post and represents the degree to which other students seek out that student for interaction, thus students with high in-degree are notable because their thoughts and opinions may be considered more important than others in the class. In contrast, students with high influence are in contact with many other students, as evidenced by the large number of discussion posts that they send to others, therefore students with low influence post fewer messages and do not contribute with information flow as much as other students. Betweenness measures the number of shortest paths from all students to all others that pass through that student. "A

betweenness measure commonly reflects an individual's potential access to information as it flows through the network" (Dawson, Macfadyen, Lockyer, & Mazzochi-Jones, 2011, p. 20).

For didactic purposes, Figure 7 shows an example of a centrality measures table sorted by number of posts in descending order. This particular table was generated by a SNA computer program named Gephi 0.8.2 and it displays anonymized IDs that correspond to 20 students in a discussion forum.



Id	posts	In-Degree	Out-Degree	Betweenness Centrality	Eigenvector Centrality
s1	6	0	4	0	0
s2	5	3	4	62.667	0.343
s3	5	4	4	79.5	1
s4	5	3	4	58.667	0.682
s5	4	3	2	53.5	0.423
s6	4	3	3	35	0.26
s7	4	2	3	4.5	0.145
s8	4	3	3	24.333	0.808
s9	4	2	2	30.167	0.405
s10	3	0	2	0	0
s11	3	2	2	20.833	0.434
s12	3	2	2	9	0.269
s13	3	3	2	22.833	0.77
s14	3	3	2	46	0.562
s15	2	3	1	14.5	0.614
s16	2	1	2	14.5	0.26
s17	1	0	0	0	0
s18	1	0	0	0	0
s19	1	4	0	0	0.886
s20	1	1	0	0	0.43

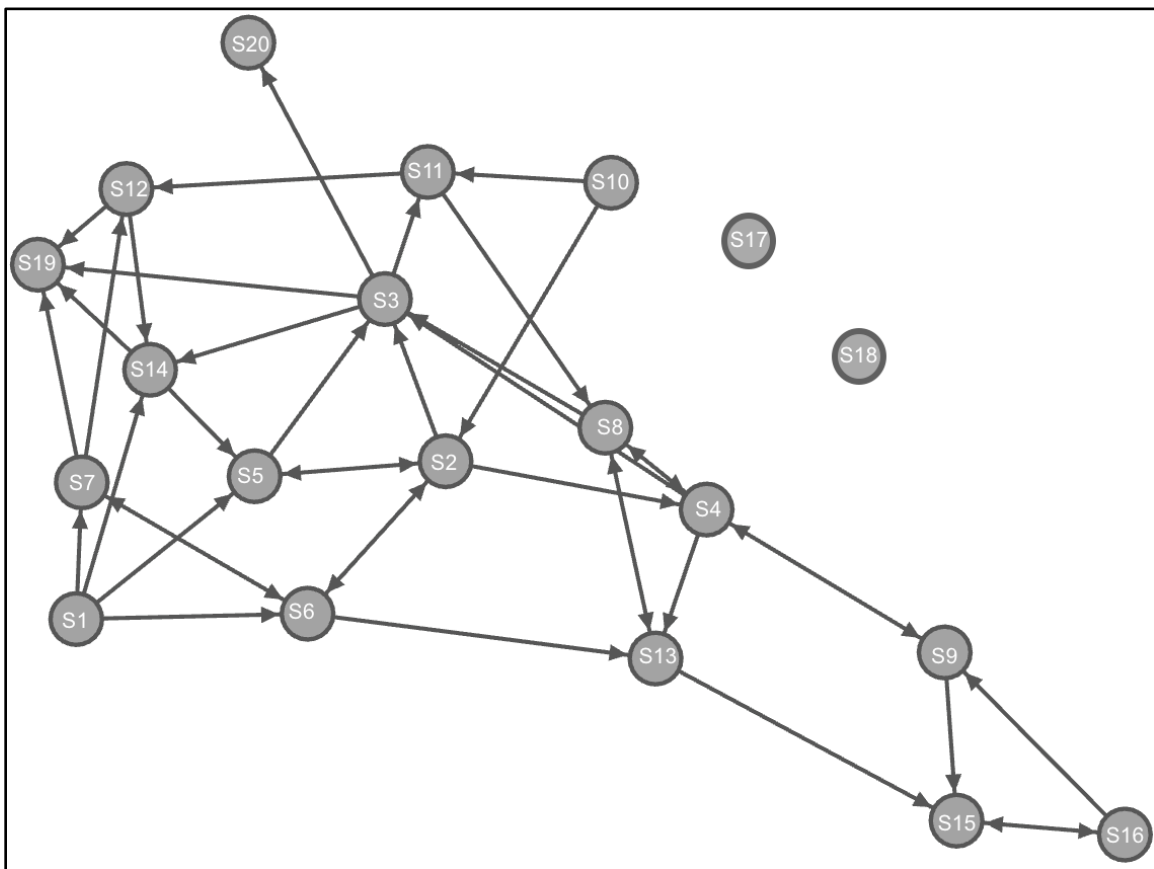
Figure 7. Example of Centrality Measures Table

It is illustrative to look at a social network diagram to see interaction patterns that emerge from a discussion forum as well as the position of different students, so the researcher derived student centrality from centrality measures tables, which he used to produce diagrams for comparing and contrasting of results between the Interaction Analysis Model and SNA.

Figure 8 shows an example of an anonymized diagram of interaction patterns that corresponds to the network data used to generate Figure 7. This kind of diagram helped to contrast both analyses.

Figure 8. Example of Social Network Diagram

In SNA terms, Figure 8 has gray circles known as actors or nodes, which represent a



student that published a post. A line with an arrow at the end is known as a directed edge and it represents a reply, i.e., one interaction. This social network diagram is one possible graphical representation of student-to-student interaction patterns that should allow the researcher to provide supplemental visual information.

The researcher mixed the Interaction Analysis Model and SNA aiming at illustrating the abstract process of knowledge construction, taking into consideration the totality of

interconnected relations that emerge from online discussion forums. As stated in the first chapter, the idea was to supplement the Interaction Analysis Model with SNA by accounting for the social aspect of knowledge construction in terms of social networks, i.e., SNA accounts for interaction dynamics based on the idea an information flow co-exists with a social relationship among students. One example of the way the researcher mixed both methods is shown in Figure 9, which is a social network diagram that includes interaction patterns identified by the Interaction Analysis Model as reported in a study by Gunawardena, Flor, Gómez, and Sánchez (2016).

Figure 9 was produced with Microsoft Excel with NodeXL and it shows actors (nodes) as dots that represent a student that published a post. A line with an arrow at the end is a directed arc or edge and it represents a reply, i.e., one interaction. This type of diagram is one possible graphical representation of student-to-student interaction patterns that provides supplemental visual information. In short, Figure 9 has edges labeled with the post number and the maximum occurring Interaction Analysis phase in parentheses. Actors with the highest in-degree (JL, JG, LM) and highest betweenness centrality (CJ) are highlighted in black along with associated edges.

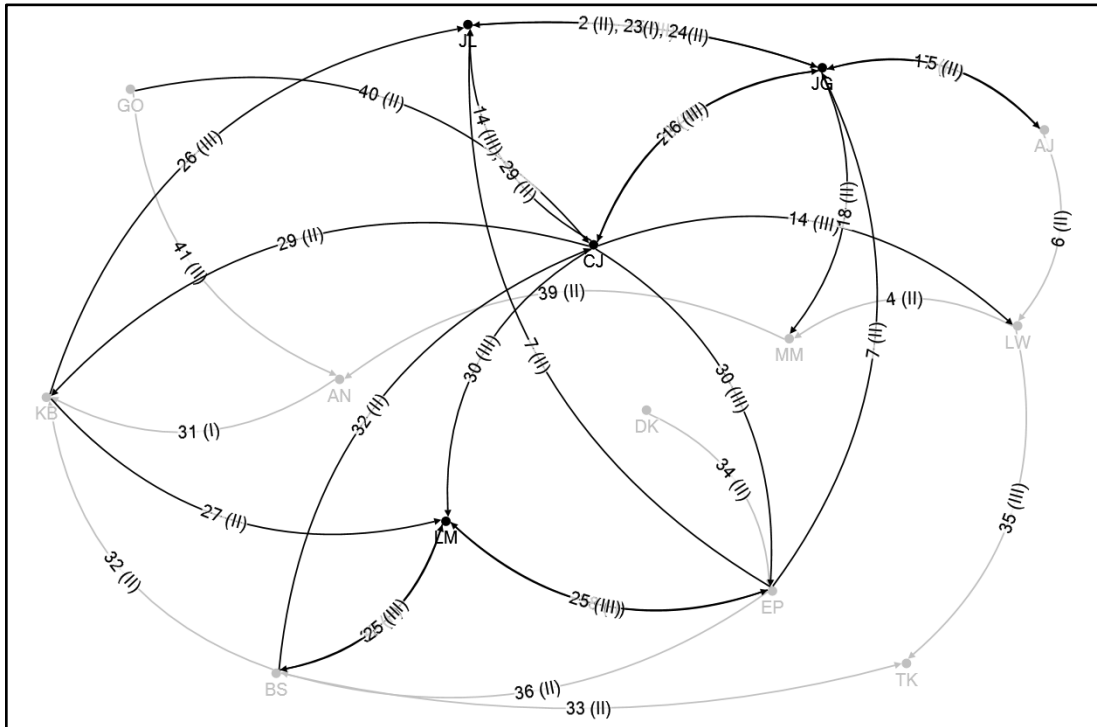


Figure 9 Example of Social Network Diagram of Interaction Patterns by Gunawardena et al. (2016)

CHAPTER FOUR: RESULTS

The researcher presented an overarching research question in the first chapter as part of the problem statement, namely, how does social construction of knowledge relate to student centrality as defined by SNA in Spanish online discussion forums conducted in Mexico? This question will be addressed at the end of this chapter after addressing the responses to the specific research questions (1a-1d), which build on each other to provide a complete explanation of social construction of knowledge and social networks.

The researcher used the Interaction Analysis Model and the social network approach to examine interaction patterns that emerge from a discussion forum. This strategy implies the researcher examined specific social networks within a group of people not the group of people as a whole. As a result, there were three social networks within the selected group of graduate students because there were three discussion forums in the dataset.

Occurrence of social construction of knowledge, characteristics of each social network, characteristics of posts published by students with high centrality, and the way higher student centrality contributes to high levels of social construction of knowledge are aspects of the study that will be addressed to explain social construction of knowledge and social networks.

RQ1a. Does knowledge construction occur through student-to-student interaction in online discussion forums as measured by the IAM?

Two coders who used the Interaction Analysis Model determined knowledge construction occurred in the three open ended non-structured forums as a result of student-to-student interaction. To reiterate, the model's analysis procedure consists of reading every post

from a discussion transcript and assigning them one or more phases for the purpose of identifying different phases of social construction of knowledge.

Table 4 presents the result of coder's work to determine occurrences of social construction of knowledge in forum 1. The two coders concurred in determining a total of 24 occurrences of knowledge construction with a level of intercoder reliability of Percent Agreement=87% (Holsti, 1969) in forum 1, which had 18 posts. Again, the Interaction Analysis Model's procedure consisted of reading every post entered into a coding spreadsheet and assigning them one or more codes in order to identify different phases of social construction of knowledge, therefore the number of overall occurrences can be larger than the total number of posts.

Table 4 indicates that in forum 1 the majority of occurrences (75%) happened at phase I, which involves students either sharing or comparing information. Twenty-five percent of occurrences were at phase III, the level that involves negotiation or co-construction of knowledge, which some students achieved by skipping phase II, the level that involves the discovery and exploration of dissonance. There were no occurrences at phase IV, the level that involves students testing tentative constructions of knowledge, and there were no occurrences of phase V either, which is the highest level that involves students making explicit statements of agreement or application of new knowledge.

Using Gunawardena et al.'s (1997) analogy of the patchwork quilt for social construction of knowledge, forum 1 would be as if a quilter has chosen the base or ground fabric and has visualized different designs, phase I occurrences being the base fabric and phase III ones the envisioned designs.

Table 4

Occurrence of Social Construction of Knowledge in Forum 1

Occurrence of Social Construction of Knowledge in Forum 1		
		%
Phase I	18	75%
Phase II	0	0%
Phase III	6	25%
Phase IV	0	0%
Phase V	0	0%
Total	24	100%

Table 5 shows the way the two coders concurred in determining a total of 36 occurrences of knowledge construction with a level of intercoder reliability of Percent Agreement=86% in forum 2, which had 13 posts. The number of overall occurrences in this forum was again larger than the total number of posts.

Table 5 indicates that in forum 2 social construction of knowledge occurred in a balanced fashion from phase I to phase III, meaning the percentage of occurrences of each phase from phase I to phase III was around 30%, which appears as a series of sequential steps towards high levels, considering the entire gestalt formed by the online interaction among students. For instance, 36% of occurrences were at phase I, the level that involves students either sharing or comparing information. A similar amount of occurrences were at phase II, the level that involves the discovery and exploration of dissonance. Likewise, 31% of occurrences were at phase III, the level that involves negotiation or co-construction of knowledge. However, the gestalt of this forum halted in phase IV as evidenced by only one occurrence at phase IV, the level that involves students testing tentative constructions of

knowledge, and there were no occurrences of phase V, which is the highest level that involves students making explicit statements of agreement or application of new knowledge.

Using again the analogy of the patchwork quilt for social construction of knowledge, forum 2 would look like a quilter has already chosen the base fabric, has discarded some pieces of fabric and selected other pieces, has visualized different designs, and is starting to test a mock-up of the quilt; phase I occurrences being the base fabric, phase II ones the process of discarding and selecting small pieces of fabric to be layered, phase III ones the envisioned designs, and the only phase IV occurrence would be the first mock-up of the quilt.

Table 5

Occurrence of Social Construction of Knowledge in Forum 2

Occurrence of Social Construction of Knowledge in Forum 2		
		%
Phase I	13	36%
Phase II	11	31%
Phase III	11	31%
Phase IV	1	3%
Phase V	0	0%
Total	36	100%

Table 6 presents the way the two coders concurred in determining a total of 33 occurrences of knowledge construction. The level of intercoder reliability or Percent Agreement=70% in forum 3, which had 15 posts. The number of overall occurrences in this forum was again larger than the total number of posts.

Table 6 indicates that in forum 3 the percentage of social construction of knowledge occurrences varied in an apparent random fashion across phases I to phase IV, but the overall occurrence still appears as a series of sequential steps towards high levels, i.e., students did not skip any phase to post at high levels. For example, almost half of all occurrences (45%) were at phase I, the level that involves students either sharing or comparing information, while 21% of occurrences were at phase II, the level that involves the discovery and exploration of dissonance. Nine percent of occurrences were at phase III, the level that involves negotiation or co-construction of knowledge. The gestalt of this forum moved on to phase IV as evidenced by almost one fourth (24%) of occurrences at phase IV, the level that involves students testing tentative constructions of new knowledge. There were no

occurrences of phase V, which is the level that involves students making explicit statements of agreement or application of new knowledge.

Going back to the analogy of the patchwork quilt, forum 3 would look like a quilter has already chosen the base fabric, has discarded some pieces of fabric and selected other pieces, has visualized different designs, and is testing different mock-ups of the quilt; phase I occurrences being the base fabric, phase II the process of discarding and selecting small pieces of fabric to be layered, phase III the envisioning designs, and phase IV occurrences the different mock-ups of the quilt. However, the quilter did not make an explicit statement about actually making the patchwork quilt as there were no phase V occurrences.

Table 6

Occurrence of Social Construction of Knowledge in Forum 3

Occurrence of Social Construction of Knowledge in Forum 3		
		%
Phase I	15	45%
Phase II	7	21%
Phase III	3	9%
Phase IV	8	24%
Phase V	0	0%
Total	33	100%

Intercoder reliability for all forums as measured by the Percent Agreement statistic, was above 85% in forum 1 and 2, and at 70% in forum 3. The latter Percent Agreement score may reflect the naturalistic nature and inductive analysis that defines qualitative inquiry.

In all forums the number of social construction of knowledge occurrences was larger than the number of posts, indicating it is possible for students to go through multiple phases

in one post. In forum 1 the majority of occurrences (75%) happened at phase I and there was no dissonance (phase II). Forum 1 had the smallest number of occurrences (24 occurrences) of all forums.

Forum 2 had the largest number of knowledge construction occurrences of all forums (36 occurrences), and there was a proportional number of occurrences from phase I through III, which appears as if interaction—as a whole—developed through phases without skipping any phase, but there was only one occurrence at phase IV and none at phase V.

Forum 3 was similar to forum 2 in that it had almost the same number of knowledge construction occurrences (33 occurrences). Also, even though there was not a proportional number of occurrences from phases I to IV interaction as a whole developed through phases without skipping any phase but there were no occurrences at phase V.

In spite of a minimal amount of student-to-student interaction due to the non-structured student centered nature of the forums, the researcher still identified social construction of knowledge occurrences in all of them. From the Interaction Analysis Model point of view, the researcher identified two different interaction patterns. First, the majority of occurrences happened at phase I, which is the beginning of the knowledge construction process. Second, considering the gestalt of each discussion forum, it appears that when students move through phases without skipping phase II, they cross the threshold of phase III (negotiation, co-construction) and are able to post at more complex phases such as phase IV.

RQ1b. What are the characteristics of the social network created by students in an online discussion forum?

In-degree, out-degree, and betweenness centrality account for student overall degree of centrality in SNA. The in-degree measure counts inbound posts (a reply to a post made by

a student) with other students while out-degree counts outbound posts (an initial post or reply sent by a student). Betweenness reflects an individual's potential access to information as it flows through the network. These measures, when considered separately, are indicators of network "prestige" (in-degree) and influence (out-degree). "Prestige" results from the number of replies directed to a student's post and represents the degree to which other students seek out that student for interaction, thus students with high in-degree are notable because their information may be considered more important than others in the discussion forum. Students with high influence are in contact with many other students, as evidenced by the large number of discussion posts that they send to others, in contrast students with low influence post fewer messages and do not contribute to the information flow as much as other students.

Table 7 contains centrality measures for forum 1, which had a density of 0.05, 1 being the maximum possible density score a social network can get. From left to right there is one version of the centrality measures for forum 1 that lists students in alphabetical order with their respective scores for number of posts, in-degree, out-degree, and betweenness centrality; next there is a slightly different version of the same centrality measures sorted first by in-degree, then by out-degree, and betweenness centrality in descending order. Note there is a student marked with an asterisk, which denotes the student who created the discussion forum's prompt about evaluating web conferencing effectiveness. In the sorted version of the centrality measures, five students with higher centrality than other students who participated in the same forum were identified, namely S21, S07, S02, S03, and S17.

Therefore, according to Table 7, student centrality in forum 1 can be explained in social networks terms as follows:

- S21 was the most prestigious student with an in-degree score of 2 and the one with more potential access to information as it flowed through the network based on the student's betweenness centrality score of 64
- S07 was the most influential student with an out-degree of 2.
- S07, S02, S03, and S17 got the same score of potential access to information based on their betweenness centrality score of 34.

Students in forum 1 were not well-connected as evidenced by the forum's social network density score of 0.05. Nevertheless, students such as S21, S07, S02, S03, and S17 acquired a specific position in the social network even though their participation in the forum was limited to one or two posts. Their position in the social network helped these students to emerge as students with high centrality.

Behind the curtain of this minimal amount of interaction, SNA's centrality measures still made it possible for the researcher to capture the student overall degree of centrality by considering first their in-degree score, then their out-degree score, and then their betweenness centrality score. It became clear that the betweenness centrality measure, being a more sophisticated measure in that it is algorithmic, is useful for identifying students with high centrality even in a scenario like forum 1 where there was a minimal amount of interaction. Betweenness centrality is algorithmic, as opposed to arithmetic (e.g., addition, subtraction, multiplication, and division), meaning is a set of rules that precisely defines a sequence or operations to calculate the number of shortest paths from all students to all others that pass through that student. "A betweenness measure commonly reflects an individual's potential access to information as it flows through the network" (Dawson et al., p. 20). The researcher used the computer program NodeXL to calculate betweenness centrality scores.

Table 7

Centrality Measures Table of Forum 1

Centrality Measures Table of Forum 1				
	Number of	Betweenness		
	Posts	In-Degree	Out-Degree	Centrality
S01	-	-	-	-
S02	1	1	1	34
S03	1	1	1	34
S04	1	0	1	0
S05	1	0	1	0
S06	1	0	1	0
S07	2	1	2	34
S08	1	0	1	0
S09	1	0	1	0
S10	1	0	1	0
S11	1	0	1	0
S12	1	0	1	0
S13	1	0	1	0
S14	1	0	1	0
S15	1	0	1	0
S16	1	0	1	0
S17	1	1	1	34
S18	-	-	-	-
S19	1	0	1	0
S20*	0	13	0	282
S21	1	2	1	64

*Prompt

Sorted Centrality Measures Table of Forum 1				
	Number of	Betweenness		
	Posts	In-Degree	Out-Degree	Centrality
S01	-	-	-	-
S18	-	-	-	-
S20*	0	13	0	282
S21	1	2	1	64
S07	2	1	2	34
S02	1	1	1	34
S03	1	1	1	34
S17	1	1	1	34
S04	1	0	1	0
S05	1	0	1	0
S06	1	0	1	0
S08	1	0	1	0
S09	1	0	1	0
S10	1	0	1	0
S11	1	0	1	0
S12	1	0	1	0
S13	1	0	1	0
S14	1	0	1	0
S15	1	0	1	0
S16	1	0	1	0
S19	1	0	1	0

*Prompt

Table 8 contains centrality measures for forum 2, which had a density of 0.14. There is a student marked with an asterisk, which denotes the student who created the discussion forum's prompt about technical support for web conferencing. To the right is the sorted version of the centrality measures for forum 2 with four students who had higher centrality than other students who participated in the same forum, namely, S03, S16, S02, and S12.

Student centrality in this forum can be explained in social networks terms as follows:

- S03 had more potential access to information as it flowed through the network based on the student's betweenness centrality score of 30, followed by S16 with a betweenness centrality score of 22
- S02 and S12 got the same score of potential access to information as it flowed through the network based on their betweenness centrality score of 12.
- S03, S16, S02, and S12, got an in-degree score of 1, therefore none of the most central students had more prestige than the others.
- S03, S16, S02, and S12, got an out-degree score of 1, therefore the most central students were equally influential in the discussion forum.

Students in forum 2 were not well-connected either, as evidenced by the forum's social network density score of 0.14. Still, students such as S03, S16, S02, and S12 acquired a specific position in the social network even though their participation in the forum was limited to one post. Their position in the social network helped these students to emerge as students with high centrality. Again, behind the curtain of this minimal amount of interaction, SNA's centrality measures allowed the researcher to capture the student overall degree of centrality by taking a closer look at their in-degree score, then their out-degree score, and then their betweenness centrality score. One more time, it became clear that the betweenness

centrality measure is useful for identifying students with high centrality in spite of a scenario like forum 2 where there was a minimal amount of interaction among students.

Table 8

Centrality Measures Table of Forum 2

Centrality Measures Table of Forum 2				
	Number of			Betweenness
	Posts	In-Degree	Out-Degree	Centrality
S01	-	-	-	-
S02	1	1	1	12
S03	1	1	1	30
S04	-	-	-	-
S05	1	0	1	0
S06	-	-	-	-
S07	-	-	-	-
S08	1	0	1	0
S09	1	0	1	0
S10	1	0	1	0
S11	1	0	1	0
S12	1	1	1	12
S13	1	0	1	0
S14	-	-	-	-
S15	1	0	1	0
S16	1	1	1	22
S17	-	-	-	-
S18	1	0	1	0
S19*	0	9	0	71
S20	-	-	-	-
S21	1	0	1	0

*Prompt

Sorted Centrality Measures Table of Forum 2				
	Number of			Betweenness
	Posts	In-Degree	Out-Degree	Centrality
S01	-	-	-	-
S04	-	-	-	-
S06	-	-	-	-
S07	-	-	-	-
S14	-	-	-	-
S17	-	-	-	-
S20	-	-	-	-
S19*	0	9	0	71
S03	1	1	1	30
S16	1	1	1	22
S02	1	1	1	12
S12	1	1	1	12
S05	1	0	1	0
S08	1	0	1	0
S09	1	0	1	0
S10	1	0	1	0
S11	1	0	1	0
S13	1	0	1	0
S15	1	0	1	0
S18	1	0	1	0
S21	1	0	1	0

*Prompt

Table 9 contains centrality measures for forum 3, which had a density of 0.06. There is a student marked with an asterisk, which denotes the student who created the discussion forum's prompt about pros and cons of web conferencing. To the right is the sorted version of the centrality measures with four students who had higher centrality, than the other students who participated in the same forum, namely, S15, S04, S17, and S21. Student centrality in this forum can be explained in social networks terms as follows:

- S15 had more potential access to information as it flowed through the network based on the student's betweenness centrality score of 52.
- S04, S17 and S21 got the same score of potential access to information as it flowed through the network based on their betweenness centrality score of 28.
- S15, S04, S17, and S21, got an in-degree score of 1, therefore none of the most central students had more prestige than the others.
- S15, S04, S17, and S21, got an out-degree score of 1, therefore none of the most central students was more influential than the others.

Students in forum 3 were not well-connected either, as evidenced by the forum's social network density score of 0.06. Nonetheless, students such as S15, S04, S17, and S21 acquired a specific position in the social network even though their participation in the forum was limited to one post. Their position in the social network helped these students to emerge as students with high centrality. Again, behind the curtain of this minimal amount of interaction, SNA's centrality measures allowed the researcher to capture the student overall degree of centrality by taking a closer look at their in-degree score, then their out-degree score, and then their betweenness centrality score. One more time, it became clear that the

betweenness centrality measure is useful for identifying students with high centrality in spite of a similar scenario in forum 3 where there was a minimal amount of interaction.

Table 9

*Centrality Measures Table of Forum 3***Centrality Measures Table of Forum 3**

	Number of Posts	In-Degree	Out-Degree	Betweenness Centrality
S01	1	0	1	0
S02	1	0	1	0
S03	1	0	1	0
S04	1	1	1	28
S05*	0	11	0	200
S06	1	0	1	0
S07	-	-	-	-
S08	1	0	1	0
S09	1	0	1	0
S10	1	0	1	0
S11	1	0	1	0
S12	-	-	-	-
S13	1	0	1	0
S14	1	0	1	0
S15	1	1	1	52
S16	-	-	-	-
S17	1	1	1	28
S18	1	0	1	0
S19	-	-	-	-
S20	-	-	-	-
S21	1	1	1	28

*Prompt

Sorted Centrality Measures Table of Forum 3

	Number of Posts	In-Degree	Out-Degree	Betweenness Centrality
S07	-	-	-	-
S12	-	-	-	-
S16	-	-	-	-
S19	-	-	-	-
S20	-	-	-	-
S05*	0	11	0	200
S15	1	1	1	52
S04	1	1	1	28
S17	1	1	1	28
S21	1	1	1	28
S01	1	0	1	0
S02	1	0	1	0
S03	1	0	1	0
S06	1	0	1	0
S08	1	0	1	0
S09	1	0	1	0
S10	1	0	1	0
S11	1	0	1	0
S13	1	0	1	0
S14	1	0	1	0
S18	1	0	1	0

*Prompt

The characteristics of a social network that emerges from an online discussion forum can be explained in terms of centrality measures obtained through SNA. Although the post is the most fundamental input required to take SNA measures, it is not a centrality measure *per se*, but it is the unit of analysis in conjunction with the student. Again, in-degree, out-degree, and betweenness centrality scores account for student overall degree of centrality as the in-degree measure counts inbound posts (replies received) from other students while out-degree counts outbound posts (post(s) published or replies sent). To reiterate, when considered separately, in-degree is an indicator of network prestige, out-degree of influence, and betweenness centrality is potential access to information as it flows through the network.

In theory, a well-connected social network has a high density, meaning everybody interacts with everybody else. On the other hand, a low density score for the social network that emerges from an online discussion forum is not necessarily "good or bad" because it is inadequate to use it as an indicator of social construction of knowledge, as explained previously in the review of literature.

In general, all forums had a low density score because student participation was limited to one or two posts. Forum 1 had a density score of 0.05, forum 2 a score of 0.14, and forum 3 a score of 0.06.

There was a similarity across forums in terms of the number of students with high centrality. In forum 1, there were 5 students with high centrality, and 4 students with high centrality in forums 2 and 3.

Across forums, when students were tied either in 2nd or 3rd place of student centrality due to same in-degree score and out-degree score, the tiebreaker was the

betweenness centrality score, which seems to be a useful centrality measure for identifying students with high centrality even in discussion forums with a minimal amount of interaction.

The characteristics of the social network created by students in an online discussion forum suggest that certain students may still emerge as students with high centrality in spite of low density due to a minimal amount of interaction. This fact led the researcher to inquire into the characteristics of posts published by students with high centrality.

RQ1c. What are the characteristics of posts published by students with high centrality?

The characteristics of posts published by students with high centrality in a given forum can be explained in connection with social construction of knowledge. This is done by combining the Interaction Analysis Model and SNA. Social construction of knowledge involves phases such as sharing/comparing of information, dissonance, negotiation/co-construction of knowledge, testing tentative constructions of knowledge, and agreement/application of new knowledge, all of which require an information flow that occurs in relation to others in the network. This information flow can in turn be explained with SNA in centrality measures terms, which reveal student centrality.

Table 10 presents students with high centrality in forum 1 with the different phases identified in their post(s). Student 21 had the highest in-degree and betweenness centrality scores, but posted at phase I by sharing/comparing information according to the Interaction Analysis Model. The student with the highest out-degree score was S07, who reached phase III by negotiating meaning/co-constructing knowledge. Students S02, S03, and S17 got the same in-degree, out-degree, and betweenness scores, so they were tied in third place of student centrality, yet student S02 reached phase III.

Table 10

Students with High Centrality in Forum 1

Students with Higher Centrality in Forum 1					
	Number of			Betweenness	Phases
	Posts	In-Degree	Out-Degree	Centrality	Reached
S21	1	2	1	64	I
S07	2	1	2	34	I, III
S02	1	1	1	34	I, III
S03	1	1	1	34	I
S17	1	1	1	34	I

As stated in the literature review, student-to-student interaction needs to be examined not only for how it happens, its frequency, timeliness or its information flow, but in terms of the intent and form, i.e., interaction needs to be examined in terms of its contribution to social construction of knowledge, so it is worth taking a closer look at the characteristics of posts published by students with high centrality in forum 1 as shown in Table 11.

Table 11 shows excerpts of what students with high centrality in forum 1 wrote in their posts to emerge as central students in spite of a low density due to a minimal amount of interaction in the forum in terms of number of posts. For example, student S21's post was the second to be published, considering the entire gestalt formed by interaction in forum 1, and it was at phase I because the student approached knowledge construction by sharing or comparing information, more specifically because the student performed the following operations as defined by the Interaction Analysis Model: 1) A statement of observation or opinion, and 2) Definition, description, or identification of a problem. These operations explain the characteristics of posts.

Another example would be student S07's post, which was the sixth to appear in forum 1, posting at phase III because the student approached knowledge construction by negotiating or co-constructing it, more specifically, the characteristics of the post as defined by the Interaction Analysis Model were: 1) Identification of areas of agreement or overlap among conflicting concepts, and 2) Proposal and negotiation of new statements embodying compromise, co-construction.

Table 11

Excerpts of posts by Students with High Centrality in Forum 1

Student	Post Number	Phases Reached	Excerpt
S21	2	I	"I think what is complex in the assessment of an audio conference is..." "...I think a good start to prevent errors is..."
S02	2.1	I, III	"I agree with you S21, if specifications are generated it is easier to carry out this type of processes, otherwise chaos ensues." "That is, there must be previous planning plus set objectives..."
S07	2.2	I	"I also agree with you S21, I would only add..."
S03	3	I	"The assessment, is a process and as such it involves planning." "I think the rubric is the appropriate instrument to assess the objective..."
S07	6	I, III	"I like the reflection of each one of you a lot, but I propose to make a more concrete list..." "I am starting the list..."
S17	11	I	"I think the premise ought to be..."

In light of the phases reached by students with high centrality, the researcher took an extra step to verify the extent to which centrality measures explain the variability of the social construction of knowledge level. Thus, multiple regression was conducted to determine which independent variables (in-degree [indegree]; out-degree [outdegree]; and betweenness centrality [betweenness]) were the predictors of the social construction of knowledge level. Regression results for forum 1 indicate an overall model that is not statistically significant, $R^2 = 0.14$, $F(3, 14) = 0.77$, $p < 0.53$. This model accounted for 14% of the variability in the social construction of knowledge level. A summary of the regression model is presented in Appendix B.

Table 12 presents the students with high centrality in forum 2 with the different phases their post(s) reached. In this forum, all students with high centrality got the same prestige (in-degree), and influence (out-degree) score. Student S03 emerged as the most central student because she/he got the highest potential access to information (betweenness centrality) score, and reached phase III experiencing negotiation of meaning/co-construction of knowledge. Student S16 was the second most central student because she/he got the second highest potential access to information score, and posted at phase II experiencing dissonance. Students S02 and S12 got the same potential access to information score and were tied in third place of student centrality, but student S02 reached phase III.

Table 12

Students with High Centrality in Forum 2

Students with Higher Centrality in Forum 2					
	Number of Posts	In-Degree	Out-Degree	Betweenness Centrality	Phases Reached
S03	1	1	1	30	I, II, III
S16	1	1	1	22	I, II
S02	1	1	1	12	I, II, III
S12	1	1	1	12	I

Having established the highest phases reached by students with high centrality in forum 2, let us take a closer look at the characteristics of their posts in Table 19.

Table 13 shows excerpts of what students with high centrality in forum 2 wrote in their posts to emerge as central students in spite of a low density in the forum. For example, student S02's post was the sixth to be published, considering the entire gestalt formed by interaction in forum 2, and it reached phase III because the student approached knowledge construction by negotiating or co-constructing it, more specifically, the characteristics of the post as defined by the Interaction Analysis Model were: 1) Identification of areas of agreement or overlap among conflicting concepts, and 2) Proposal and negotiation of new statements embodying compromise, co-construction.

Another example would be student S03's post, which was the ninth to appear in forum 2, reaching phase III because the student approached knowledge construction also by negotiating or co-constructing it, more specifically, the characteristics of the post as defined by the Interaction Analysis Model were: 1) Identification of areas of agreement or overlap among conflicting concepts, 2) Negotiation of the relative weight to be assigned to types of argument, and 3) Proposal and negotiation of new statements embodying compromise, co-construction.

Table 13

Excerpts of Posts by Students with High Centrality in Forum 2

Student	Post Branch Number	Phases Reached	Exerpt
S02	6	I, II, III	<i>"I absolutely agree with you." "...I say this based on my experience..." "...I suggest we use..."</i>
S03	9	I, II, III	<i>"I concur with you..." "Going back to the logistics that were discussed during the sessions..." "... as we have seen..." "I conclude we must be objective when we come up with a plan that includes..."</i>
S16	9.1	I, II	<i>" When I reviewed each of your interventions, I concur with your contributions..." "... we will be able to focus our attention precisely on..." "... that helps us make our work more efficient in the teaching-learning process."</i>
S12	9.1.1	I	<i>" Regarding your comment S16 I also think..."</i>

Again, to verify the extent to which centrality measures explain the variability of the social construction of knowledge level the researcher conducted a multiple regression to determine which independent variables (in-degree [indegree]; out-degree [outdegree]; and betweenness centrality [betweenness]) were the predictors of the social construction of knowledge level. Regression results for forum 2 indicate a statistically significant overall model, $R^2 = 0.63$, $F(3, 9) = 5.20$, $p < 0.02$. This model, specifically in-degree, accounted for 63% of the variability in the social construction of knowledge level. A summary of the regression model is presented in Appendix B.

Table 14 presents the students with high centrality in forum 3 along with the different phases their post(s) reached. In this forum all students with high centrality were equally prestigious and influential because they got the same prestige (in-degree), and influence (out-degree) score. Student S15 got the highest potential access to information (betweenness centrality) score and reached phase IV by testing tentative constructions of knowledge. Students S04, S17, and S21 were tied in third place of student centrality because they got the same potential access to information (betweenness centrality) score, yet students S04 and S17 reached phase IV.

Table 14

Students with High Centrality in Forum 3

Students with Higher Centrality in Forum 3					
	Number of	Betweenness			Phases
	Posts	In-Degree	Out-Degree	Centrality	Reached
S15	1	1	1	52	I, II, IV
S04	1	1	1	28	I, IV
S17	1	1	1	28	I, II, IV
S21	1	1	1	28	I, II

Again, having established the highest phases reached by students with high centrality in forum 3, let us take a closer look at the characteristics of their posts in Table 21.

Table 15 shows excerpts of what students with high centrality in forum 3 wrote in their posts to emerge as central students in spite of a low density in the forum. For example, student S15's post was the first to be published, considering the entire gestalt formed by interaction in forum 3, and it reached phase IV because the student approached knowledge construction by testing tentative constructions of it, more specifically, the characteristics of the post as defined by the Interaction Analysis Model were: 1) Testing against personal experience.

Another example would be student S17's post, which was the fifth to appear in forum 3, reaching phase IV because the student approached knowledge construction also by testing tentative constructions of it, specifically, the characteristics of the post were: 1) Testing against personal experience. One more example would be student S04's post, which was the tenth to appear in forum 3, reaching phase IV because the student approached knowledge construction also by testing tentative constructions of it, specifically, the characteristics of the post were: 1) Testing the proposed synthesis against "received fact" as shared by the participants and/or their culture, and 2) Testing against existing cognitive schema.

Table 15

Excerpts of Posts by Students with High Centrality in Forum 3

Student	Post Branch Number	Phases Reached	Exerpt
S15	1	I, II, IV	<p><i>"I have never had a video conference at the level S05 had where... but I have had some where..."</i></p> <p><i>"I ran video conferences..."</i></p> <p><i>"The difficulties we generally used to have..."</i></p> <p><i>"Clearly these classes required a minimum of two weeks of planning..."</i></p> <p><i>"I must conclude that..."</i></p>
S21	1.1	I, II	<p><i>"Well my experience with audio and video conferencing..."</i></p> <p><i>"... it is impossible for me to separate the two..."</i></p> <p><i>" From these experiences I must confess..."</i></p>
S17	5	I, II, IV	<p><i>"The use I gave the audio and video conference at some point in time was not..."</i></p> <p><i>"It is clear to me that..."</i></p>
S04	10	I, IV	<p><i>"I did not have experiences with video conferencing per se."</i></p> <p><i>"It would have been a solution for a time in which I worked from home though..."</i></p> <p><i>"Had we implemented this technology..."</i></p>

Once more, to verify the extent to which centrality measures explain the variability of the social construction of knowledge level the researcher conducted a multiple regression to determine which independent variables (in-degree [indegree]; out-degree [outdegree]; and betweenness centrality [betweenness]) were the predictors of the social construction of knowledge level. Regression results for forum 3 indicate an overall model that is not statistically significant, $R^2 = 0.11$, $F(3, 11) = 0.47$, $p < 0.71$. This model accounted for 11% of the variability in the social construction of knowledge level. A summary of the regression model is presented in Appendix B.

The characteristics of posts published by students with high centrality in all three forums indicate that in certain instances like forum 1 interaction can skip phase II and still develop at high levels of knowledge construction without experiencing dissonance, but this approach to knowledge construction may not be beneficial as it became clear that forum 1 was the only one without any phase IV or V occurrences, furthermore it had almost half as many phase III occurrences than forum 2, in which students experienced the most dissonance of all three forums. Therefore, dissonance may have a positive impact on social construction of knowledge as phase II seems to be necessary for interaction to develop at high levels.

In this vein, dissonance matters as much as students with high centrality because they seem to work in tandem, especially as those students with the highest betweenness centrality (potential access to information) score write posts with characteristics that allow other non-central students to post at more complex phases of knowledge construction.

Going back to the analogy of the patchwork quilt from the Interaction Analysis Model, a quilter with access to an ample variety of materials will have the possibility to discard many pieces of fabric and select many other pieces. Consequently, the quilter might

be able to visualize a myriad of designs, which in turn may increase the chances of actually making the quilt, as opposed to having very limited choices and having to manage with the limited or inadequate means available or no choices at all. Phase II or dissonance in the social construction of knowledge process gives students the possibility to discard some information and select other, as there is discussion of what is relevant or agreed upon and what is not. On the other hand, phase III or negotiation/co-construction of knowledge helps students to consider potential ramifications of new ideas as they make sense of them both internally and by interacting with other students, which in turn may increase their chances of making statements of actual applications of new knowledge.

The 5 most central students in forum 1 posted at phase I, 71% of the time. Phase I is the beginning of the social construction of knowledge process. The rest of the time, they posted at phase III. None of them posted at phase II. The characteristics of posts published by central students in forum 1 suggest they might have affected the possibility of interaction developing at a high levels of knowledge construction by skipping phase II and not posting at more complex phases.

The 4 most central students in forum 2 were different than the 4 most central students in forum 3. With the exception of one student, all central students both in forum 2 and forum 3 posted at a variety of phases ranging from phase I to phase IV. The characteristics of posts published by 3 out of 4 central students in forum 2 show evidence of dissonance at phase II, and negotiation/co-construction of knowledge at phase III.

Similarly, the characteristics of posts published by 3 out of 4 central students in forum 3 show evidence of dissonance at phase II, and testing tentative constructions at phase IV.

Therefore, the characteristics of posts published by students with high centrality in forums 2 and 3 suggest they might have impacted positively the possibility of interaction developing at high levels of knowledge construction.

These observations led the researcher to make an effort to verify whether students with high centrality contribute to a higher level of social construction of knowledge or not.

RQ1d. Does higher student centrality contribute to a higher level of social construction of knowledge?

In all forums, some posts are more important than others depending both on their characteristics and the way they help students adopt more central positions. Students contribute differently to interaction by performing different operations defined by the Interaction Analysis Model, for example while some students share and compare information to start the discussion and others disagree. Thus, it was necessary for the researcher to analyze posts in relation to the larger context of the forum, which prompted him to present a narration of particular interaction sequences that clearly show how certain students with high centrality contribute to a high level of social construction of knowledge.

In forum 1 there were 6 phase III occurrences of social construction of knowledge. Eighty-three percent (5 out of 6) of these occurrences can be connected to students with high centrality in that forum, who interacted with other non-central students creating interaction sequences to some of these high level occurrences. If we zoom in on the elements of these sequences we arrive to the explanation of the way high student centrality contributes to a high level of social construction of knowledge.

Table 16 presents 4 different interaction sequences to high level occurrences in forum 1 that some central students created with other non-central students. For example, interaction

sequence A was the interaction sequence created by students S21, S02, and S19. Student S21 was the most central student in forum 1 and posted at phase I. Student S02 was the 3rd most central student and reached phase III. Student S19 was not a student with high centrality but reached phase III by interacting with students with high centrality on interaction sequence A.

Table 16

Interaction Sequences to High level Occurrences of Social Construction of Knowledge in Forum 1

	Phase Reached	I		III		III
Interaction Sequence A	Student	S21	<	S02	<	S19
	Student Centrality	1st		3rd		-
	Phase Reached	I		III		III
Interaction Sequence B1	Student	S21	<	S07	<	S09
	Student Centrality	1st		2nd		-
	Phase Reached	III bis		III bis		
Interaction Sequence B2	Student	S07	<	S09		
	Student Centrality	2nd		-		
	Phase Reached	I		III		
Interaction Sequence C	Student	S17	<	S12		
	Student Centrality	5th		-		

To illustrate the characteristics of posts associated with interaction sequences to high level occurrences in Table 16, the researcher narrates what students wrote in interaction sequence A of forum 1.

Student 20 initiated discussion forum 1 with a prompt about evaluating web conferencing effectiveness, writing "*How can we assess whether the objective was met in an audio [web] conference? What mistakes must we avoid to reach the objectives?*"

Student S21, published post number 2, writing "***I think what is complex in the assessment of an audio conference is*** (phase I) *that, even though learning is the ultimate goal we cannot only assess learning, but its pedagogical design and the channel, which is why I think a good start to prevent errors is* (phase I) *to create a "checklist," that is an instrument of fast control that guarantees material conditions are ideal for our audio conference. Then there is the pedagogical design, which can be assessed with an assessment matrix, or rubrics. and [sic] finally there is the aspect of learning and for which an assessment occurs to me.*" Student 21 had the highest overall degree of centrality.

Student S02, published post number 2.1, replying to student S21 writing "***I agree with you S21, if specifications are generated it is easier to carry out this type of processes, otherwise chaos ensues.*** (phase I) ***That is, there must be previous planning plus set objectives*** (phase III) *and if elements exist; well-structured message [sic], the channel without interruptions; if at all possible (in the case of the internet) and at the end you achieve interaction, satisfying the purpose considered in the objective, this way you achieve effective communication.*" Student S02 was in 3rd place of overall degree of centrality

Student S19, was not identified as a central student, but benefited from interaction sequence A of forum 1 because it lead she/he to phase I and phase III by publishing post

number 2.1.1. in reply to student S02. Student 19 wrote "***I concur with you S02, (phase I) especially because I think that in order to be able to evaluate a web conference's achievement it is fundamental to achieve interaction, I think that every single objective set, can be verified and assessed through interactions as long as they clear, from the most fundamental step like making sure they can hear you and communication is being achieved to verifying that participants really understood what was meant to be transmitted.***" (phase III) *Greetings!*"

In forum 2 there were 11 occurrences of phase III, and 1 of phase IV, that is a total of 12 high level occurrences. Thirty-three percent (4 out of 12) of these high level occurrences can be connected to students with high centrality in that forum, who interacted with other non-central students creating interaction sequences to some of these high level occurrences.

Zooming in on the elements of these interaction sequences, Table 17 presents 2 different interaction sequences to high level occurrences in forum 2 that some students with high centrality created with other non-central students. For example, interaction sequence A was the interaction sequence created by students S03, S16, S12, and S21. Student S03 was the most central student in forum 2 and reached phase III. Student S16 was the second most central student and posted at phase II. Student S12 was the fourth most central student and posted at phase I. Student S21 was not a central student but reached phase IV by interacting with students with high centrality on interaction sequence A.

Table 17

Interaction Sequences to High level Occurrences of Social Construction of Knowledge in Forum 2

	Phase Reached	III		II		I		IV
Interaction Sequence A	Student	S03	<	S16	<	S12	<	S21
	Student Centrality	1st		2nd		4th		-
	Phase Reached	III		III				
Interaction Sequence B	Student	S02	<	S09	<			
	Student Centrality	3rd						

To illustrate the characteristics of posts associated with the interaction sequences to high level occurrences in Table 17, the researcher narrates what students wrote in interaction sequence A of forum 2.

Student 19 initiated discussion forum 2 with a prompt about technical support for web conferencing, writing "*my contribution is very simple, I think taking the experiences we have had in the course as a starting point, it is fundamental to have a network and technical tools that guarantee us communication. In order to use this resource for educational purposes we have to rely on adequate infrastructure and specialized technical support, even though we can use free web tools given their own limitations due to the fact they are open they cannot guarantee us planning freedom or a good coverage. Working with these tools requires one focuses too much on technical aspects that may arise during the communication, so it is possible but not ideal.*"

Student S03 published post number 9 writing "*Hi S19! **I concur with you** (phase I) regarding the importance of technical support, because the success of our video conference will depend a great deal on it. As some classmates comment it is necessary to take into consideration the following points in the preparation of a videoconference: Planning, Technical Support, Resources, Assessment. **Going back to the logistics that were discussed during the sessions**, (phase II) it is necessary not to lose sight of the collaborative work its preparation involves, this way we would be talking about three key moments: before, during, and after the videoconference. Thus, it can be verified that better results will be obtained with technical support and equipment as the one in the interactive video network of U de G. On the other hand, **as we have seen** (phase II) through gmail and scopia, they offer us other characteristics to carry out a video conference, in a simpler way, though with more*

difficulties. I conclude we must be objective when we come up with a plan that includes (phase III) *the aforementioned elements by verifying the resources available to the instructor and the student, taking them as a starting point, attainable purposes will be established, so by the end of our video conference we do not think everything was a failure."* Student S03 had the highest overall degree of centrality.

Student S16 published post number 9.1 in reply to student S03 writing "*Hello everybody. When I reviewed each of your interventions, I concur with your contributions,* (phase I) *specially on the importance logistics have in an educational video conferencing session, because when this part is resolved, we will be able to focus our attention precisely on* (phase II) *meeting the objectives we are really interested in this type of session, as opposed to being distracted with audio, video, and connectivity problems. Provided [sic] video conferencing is a support tool that helps us make our work more efficient in the teaching-learning process* (phase II)." Student S16 was in 2nd place of overall degree of centrality

Student S12, published post number 9.1.1 at phase I in reply to student S16 writing "*regarding your comment S16 I also think* (phase I) *timely and correct planning minimizes the possibilities of error, in that, we increase chances of success."* Student 12 was in 4th place of overall degree of centrality.

Student S21, was not identified as a central student, but benefited from interaction sequence A of forum 2 because it lead she/he to phases I, III, IV by publishing post number 9.1.1.1 in reply to student S12. Student 21 wrote "*hello everybody! One of the problems of going into the forum by the end is that there is little to say, technical and pedagogical difficulties have been pointed out.* (phase I) *Thank you S12 for the timely summary. I would*

*like to emphasize the importance of socializing knowledge, meaning the possibility to construct my own knowledge by interacting with others and how valuable this tool would be for that purpose. However, it seems to me that if the instructor must "fight" with technical aspects it is very probable this undermines her instructional approach, I am not positive, unlike S11, that us instructors have to know it all... **certainly we got started on a road that has been traveled recently, we will see where it leads us,** (phase III) in the meantime people are talking more about interdisciplinary teams. In socialization, the scaffolding (support) the instructor does is of vital importance, moderating different contributions, because **it is not about each person presenting their little piece, but about reaching a dialogue and collaborative work, therefore I think that technical difficulties that obstruct communication or cut contributions end in a poor construction...** (phase IV) Too few and unpleasant have been my experiences with web conferencing, perhaps that is why I focus so much in the technical part, perhaps because it is the most obvious and the one that can interrupt the learning process. Does anyone have a different opinion?"*

In forum 3 there were 3 occurrences of phase III, and 8 of phase IV, that is a total of 11 high level occurrences. Thirty-six percent (4 out of 11) of these high level occurrences can be connected to students with high centrality in that forum, who interacted with other non-central students creating interaction sequences to some of these high level occurrences.

Zooming in on the elements of these interaction sequences, Table 18 presents 2 different interaction sequences to high level occurrences in forum 3 that some students with high centrality created with other non-central students. For example, interaction sequence A was the interaction sequence created by student S17, and S02. Student S17 was the third most central student in forum 3 and reached phase III. Student S02 was not a central student but reached phase IV by interacting with the student with high centrality on interaction sequence A.

Table 18

Interaction Sequences to High level Occurrences of Social Construction of Knowledge in Forum 3

	Phase Reached	III		IV
Interaction Sequence A	Student	S17	<	S02
	Student Centrality	3rd		-
	Phase Reached	IV		IV
Interaction Sequence B	Student	S04	<	S13
	Student Centrality	2nd		-

To illustrate the characteristics of posts associated with the interaction sequences to high level occurrences in Table 18, the researcher narrates what students wrote in Interaction Sequence B of forum 3.

Student 05 initiated discussion forum 3 with a prompt about pros and cons of web conferencing. Due to the length of this prompt, the researcher split it in two parts, the first part is presented here, while the second part can be found in Appendix A. Student 05 wrote *"In 2011, I had the opportunity to work in the Pan American Games Guadalajara 2011. Before the event there were technical meetings with national Olympic committees, which presidents and their council attended, to agree upon technical issues of each discipline, assistance the entire committee would get from the host, such as: transportation, meals, lodging, laundry service, stay, etc. Some countries with limited resources, such as Saint Kitts and Nevis, Netherlands Antilles and others, could not travel to attend this meeting, as they argued their budget only allowed them to travel to the actual games, along their athletes, so it was decided to carry out informative and decision making sessions through audio [web] conference."* In the second part of the prompt, Student 05 listed both pros and cons using several bullet points.

Student S04, published post number 10 writing *"I did not have experiences with video Conferencing per se. (phase I) It would have been a solution for a time in which I worked from home though, (phase IV) sending and receiving information through email, but a lot of information was lost, at the time of explanations, because it was an asynchronous connection. Had we implemented this technology [sic] (phase IV) the programing projects we were developing we would have completed them in less time and with more efficiency."* Student 04 was in 2nd place of overall degree of centrality.

Student S19, was not identified as a central student, but benefited from interaction sequence B of forum 3 because it lead she/he to phases I and IV by publishing post number 10.1 in reply to student S04. Student S19 wrote "*Good day everybody. **My experience in audio and video conference is very little** (phase I) *as I have only used the phone for an audio conference and I have only seen video conferencing in movies, but **now that I have experienced them as a learning tool, I think they are very useful** (phase IV) when there are time and distance constraints. Furthermore, it allows us to interact with others, as long as it planned appropriately. In my experience in this workshop, **I learn a lot by discovering the way to plan and carry out a video conference,** (phase IV) from conceiving the topic to unexpected events and difficulties that occurred. Thank you."**

The interaction sequences to high levels of social construction of knowledge presented above allowed the researcher to verify the extent to which high student centrality contributes to a high level of social construction of knowledge. These type of interaction sequences were found in all three forums and they lend support to a couple of ideas. First, not all occurrences at more complex phases can be connected to students with high centrality in a given forum. Second, interaction between students with high centrality and non-central students is consistent in that non-central students benefit from these interaction sequences because they allow them to post either at the highest phase reached by central students and in some instances even at higher phases.

Up to this point in the study the researcher has found evidence to explain how knowledge construction occurred through student-to-student interaction in all three discussion forums as measured by the Interaction Analysis Model and SNA. Also, he characterized the social network created by students in each online discussion forum and the

posts published by students with high centrality, and identified the way high student centrality contributes to a high level of social construction of knowledge.

RQ1. How does social construction of knowledge relate to student centrality as defined by SNA in Spanish online discussion forums conducted in Mexico?

Social construction of knowledge as defined by Gunawardena et al. (1997) is a function of interaction. Interaction in online discussion forums was the main focus of this study as it is a construct that emerges from the overlap between the Interaction Analysis Model and SNA because interaction involves an information flow that coexists with a social relation among students. This conceptual overlap allowed the researcher to mix both methods in the sense SNA supplemented the Interaction Analysis Model by accounting for the social aspect of knowledge construction with evidence of the basic generation of knowledge arising in and out of interaction within social networks of students that emerge from online discussion forums.

Figure 10 shows the social network diagram of interaction patterns that emerged from forum 1. At the center of the diagram there is a circle labeled S20, which is the pseudonym of the actor/student that created forum 1 by posting a prompt about evaluating web conferencing effectiveness. Edges are depicted with arrows showing the direction of information flow. These edges are labeled with an Arabic numeral indicating the post number and a roman number in parenthesis indicating the Interaction Analysis Model's phase reached by the student with that post. The diagram's edges are laid out like the hands of a clock.

According to the forum's entire interaction sequence, Figure 10 shows how students S21, S02, S19, S07, S03, S16, S09, S17, and S12 either got a reply or responded to a reply. These students were involved in a flow of information or specific interaction sequence that

allowed particular individuals to post at complex phases of social construction of knowledge. To be more specific S02, S19, S09, and S12 reached phase III by interacting with their classmates, as opposed to other students who reached the same phase only by replying to the prompt. It is also possible to see how students S21, S02, S03, S07, and S17 enabled the flow of information between the prompt and other students.

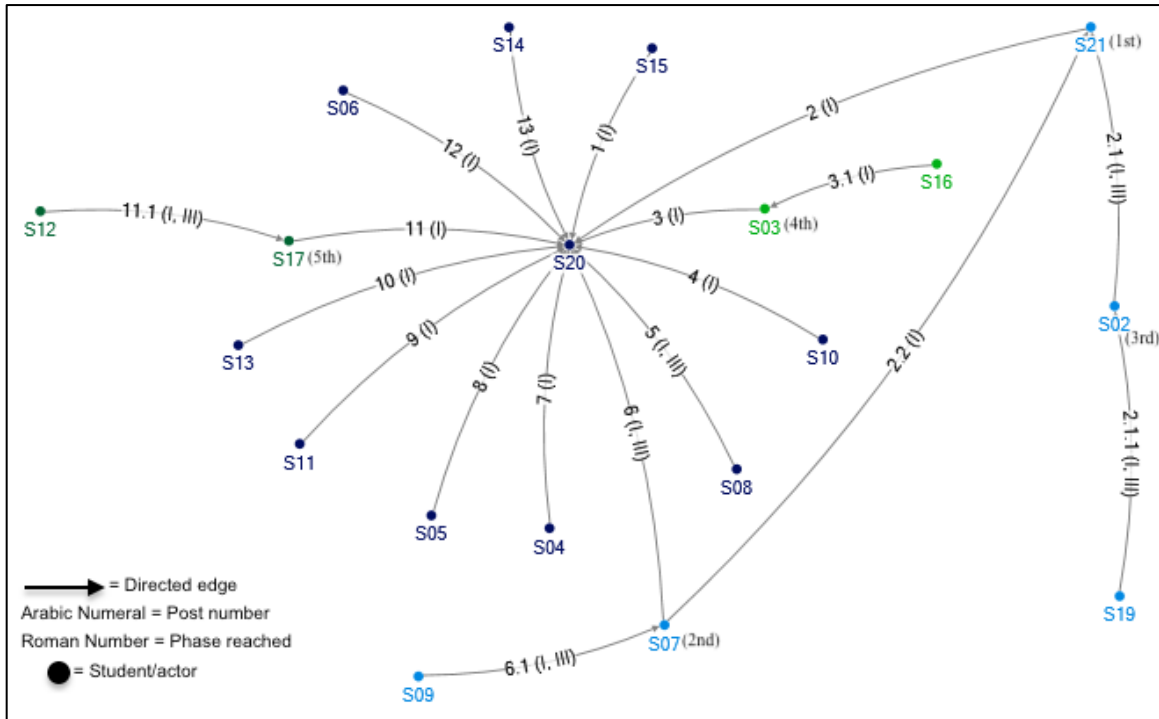


Figure 10 Social Network Diagram of Interaction Patterns in Forum 1

Figure 11 shows the social network diagram of interaction patterns that emerged from forum 2. At the center of the diagram there is a circle labeled S19, which is the pseudonym of the actor/student that created forum 2 by posting a prompt about technical support in web conferencing.

According to the forum's entire interaction sequence, Figure 11 shows how students S02, S09, S03, S16, S12, and S21 either got a reply or responded to a reply involved in a flow of information or specific interaction sequence that allowed some of them to post at complex phases of social construction of knowledge. For example, student S09 reached phase III by responding to a reply posted by S02. Likewise, student S21 reached phases III and IV by responding to S12, who in turn responded to the response of a reply. It is also possible to see how students S02, S03, S16, and S12 enabled the flow of information between the prompt and other students.

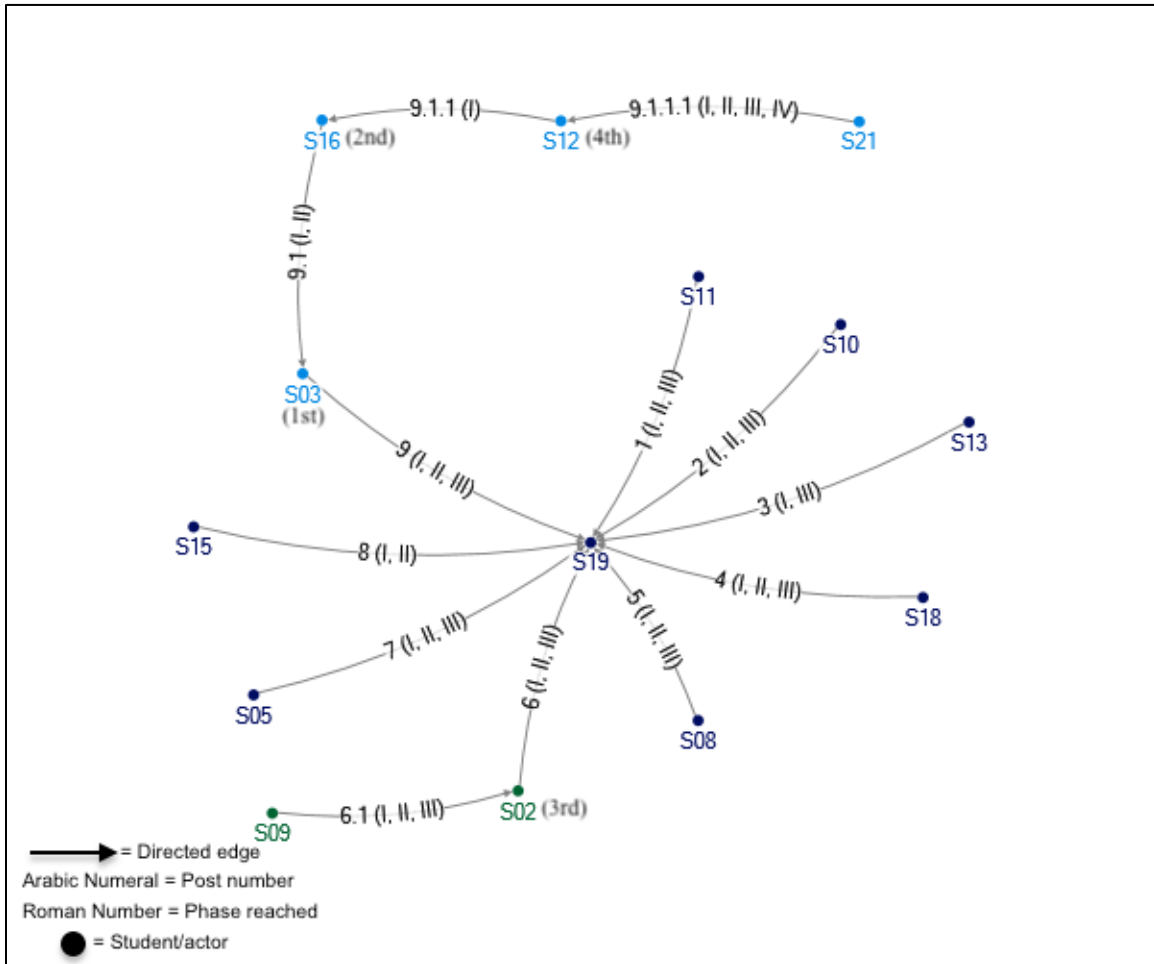


Figure 11 Social Network Diagram of Interaction Patterns in Forum 2

Figure 12 only shows the posts that contained phase II to draw more attention to the occurrence of dissonance in the social network diagram of forum 2. In this diagram only two posts were removed because they did not contain phase II. The posts removed were 9.1.1 by S12 and 3 by S13.

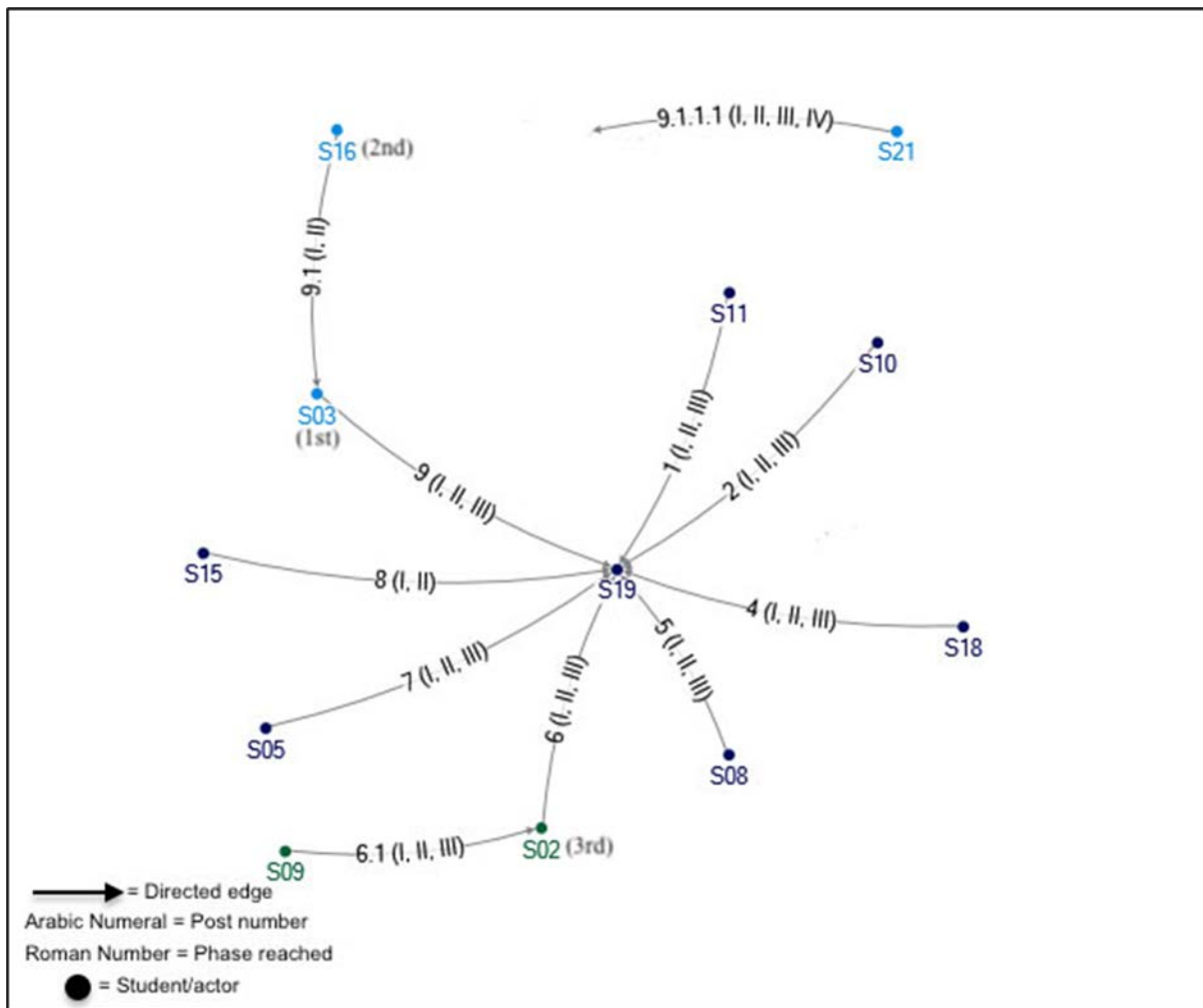


Figure 12 Social Network Diagram of Posts Containing Phase II (dissonance) in Forum 2

Figure 13 shows the social network diagram of interaction patterns that emerged from forum 3. At the center of the diagram there is a circle labeled S05, which is the pseudonym of the actor/student that created forum 3 by posting a prompt about the pros and cons of web conferencing.

According to the forum's entire interaction sequence, Figure 13 shows how students S15, S21, S09, S17, S02, S04, and S13 either got a reply or responded to a reply involved in a flow of information or specific interaction sequence that allowed some of them the post at complex phases of social construction of knowledge. For instance, student S02 and S13 reached phase IV by interacting with their classmates, as opposed to other students who reached the same phase on their own only by replying to the prompt. It is also possible to see how students S17 and S04 enabled the flow of information between the prompt and other students, who reached higher phases than them.

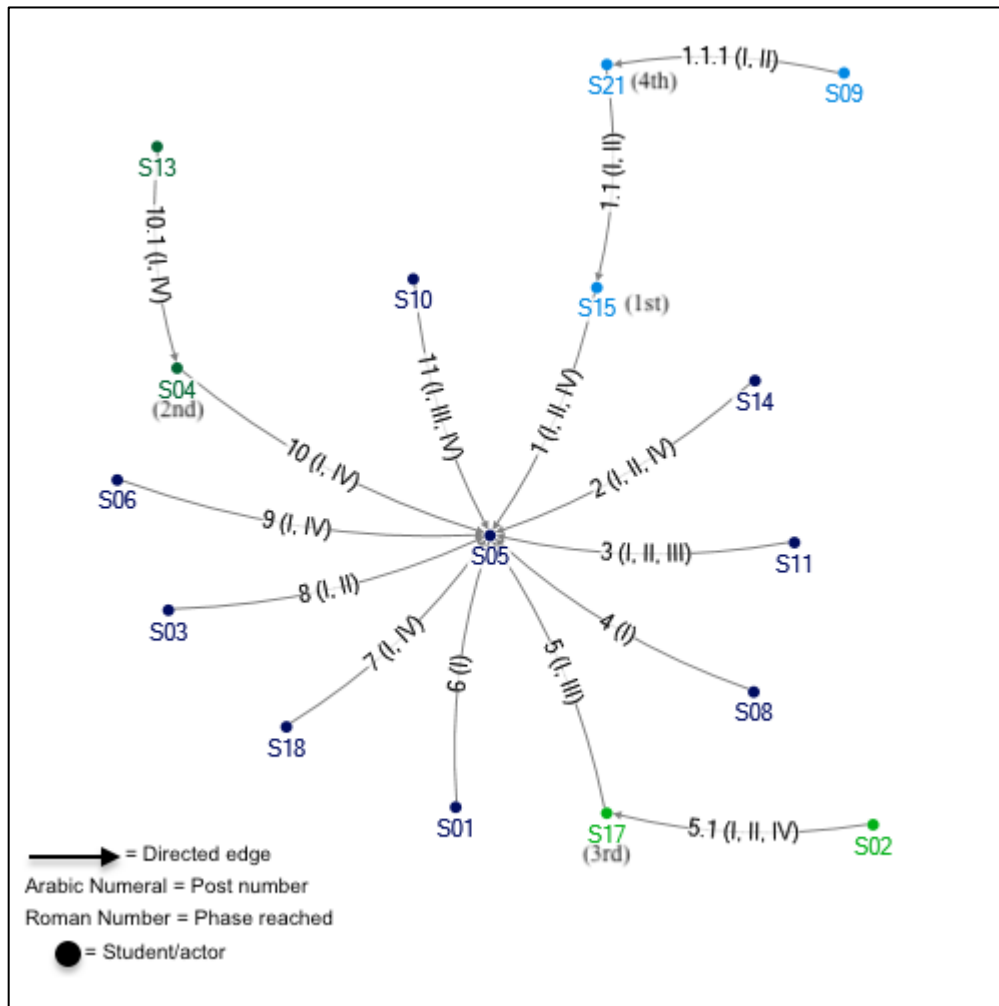


Figure 13 Social Network Diagram of Interaction Patterns in Forum 3

Figure 14 only shows the posts that contained phase II to draw more attention to the occurrence of dissonance in the social network diagram of forum 3. In this diagram 8 posts were removed because they did not contain phase II. Six posts were left in the diagram because they contained phase II, meaning 53% of the total number of posts contained dissonance.

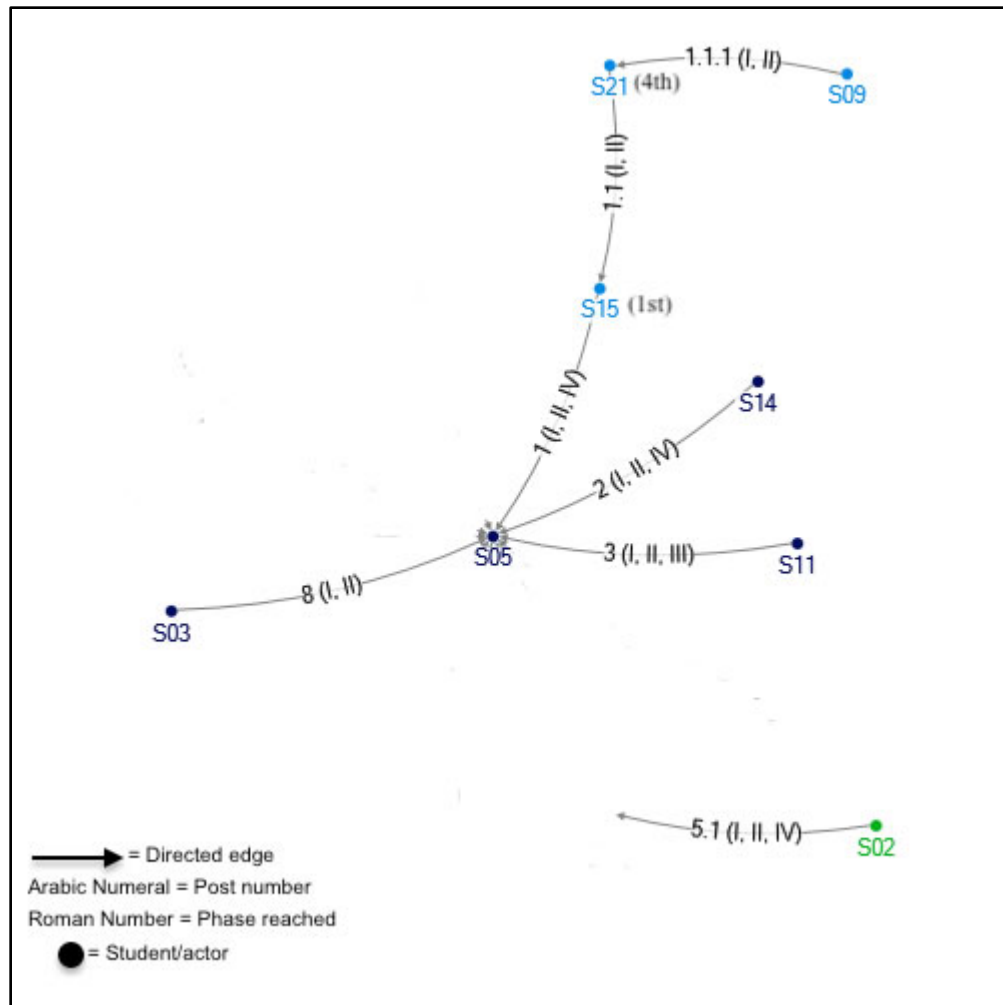


Figure 14 Social Network Diagram of Posts Containing Phase II (dissonance) in Forum 3

High density in a discussion forum may yield a "false positive" in terms of social construction of knowledge. This issue was the rationale behind combining social network diagrams with results from the Interaction Analysis Model, not only as a way to identify particular interaction patterns, but as a way to have the ability to "zoom in" on those interaction patterns or interaction sequences to pinpoint the source of high levels of social construction of knowledge by characterizing posts and replies, which ultimately reveal the characteristics of social construction of knowledge and social networks.

According to SNA, the maximum density score possible is 1. The three discussion forum social networks examined in this study had a very low density close to 0.0, meaning students were not well-connected, furthermore there was a small number of posts and replies as students limited their participation to a one-time post or reply in any given forum. Nevertheless, the mixed methods approach used in this study was capable of measuring student centrality at the most minimum level of student-to-student interaction.

Social network diagrams made it possible for the researcher to identify interaction patterns in each discussion forum and their connection with social construction of knowledge. These patterns show an apparent positive relationship between high student centrality and high levels of social construction of knowledge. However, the highest phase identified in these patterns or interaction sequences was phase IV, probably due to the open ended and non-structured kind of discussion forums. While this finding is revealing it does not imply students with high centrality are absolutely necessary for non-central students to be able to post at more complex phases, but it does imply central students bring the benefit of dialogue for students.

Social network diagrams provide visual representations of interaction patterns. The downside of this type of diagrams is that they cannot depict interaction patterns over time because they are a snapshot of a moment and they can be notoriously difficult to interpret out of context or without adding supplemental descriptive information.

It made sense for the researcher to approach interaction patterns from a SNA's structuralist position, particularly by looking at the kinds of social networks that lead to particular outcomes, such as high student centrality contributing to high levels of social construction of knowledge through a mechanism known as transmission, which in this study is transmission of information.

Studying social construction of knowledge from a network perspective required mapping the sociological concept of interaction onto particular network forms or diagrams. Thus, studying the effect of interaction patterns within networks on the phenomenon of social construction of knowledge, made social network diagrams meaningful because of the social effect these patterns may have.

The researcher made the sound decision to consider one discussion forum as one whole network (focused on all actors rather than any particular one), as opposed to an ego network (focused on the network surrounding one actor, known as the ego). This decision made it possible for the researcher to focus the analysis on the entire gestalt of an online discussion forum with the help of diagrams. This decision resulted in the collection and examination of data from a single type of student, meaning every student could conceivably be connected to any other student in one particular forum, but not across forums, or across courses. This type of examination is known as examining one-mode networks, as opposed to two-mode networks.

Consequently, it was necessary for the researcher to measure interaction one discussion forum at a time using directed ties/relations (posts, replies), which go from one student to another and which may be reciprocated. Therefore, the real value or strength of posts and replies was associated to the social construction of knowledge phase they reached.

CHAPTER FIVE: DISCUSSION AND CONCLUSION

The vital relevance of global interdependence, information societies and learning societies, and the uneven distribution of knowledge, point to a lack of official adherence to social constructivist approaches to instruction, especially for younger generations. This observation was reported by Delors (1998) and the International Commission on Education for the Twenty-first Century to UNESCO. They identified four pillars of education: learning to know, learning to do, learning to live together, and learning to be. The social pillar, learning to live together, was highlighted as the most needed to promote favorable conditions for effective learning, lending support to the need for educators, to promote individual knowledge construction as much as social learning, particularly through dialogue, which is why is important to look at student centrality.

In spite of a myriad of studies related to student-to-student interaction in online discussion forums published since the 2000s, there is inadequate literature about the orchestration of discussion forums that foster interaction aimed at generating high levels of social construction of knowledge. Literature is inadequate in the sense there is an abundance of literature on social construction of knowledge associated with the Interaction Analysis Model, SNA, and mixed methods applied to discussion forums carried out in undergraduate online courses from English speaking developed countries.

There is a scarcity of prior research reports that look at discussion forums from a different sociocultural context. This scarcity prompted the researcher to delimit his study to a graduate online course on web conferencing in Spanish within the Mexican sociocultural context.

Literature on social construction of knowledge revealed that several researchers who used Gunawardena et al.'s (1997) Interaction Analysis Model to study social construction of knowledge as a function of online interaction have demonstrated its adequacy (e.g., De Wever, Van Keer, Schellens, and Valcke, 2010; Heo, Lim, and Kim, 2010; and Chai and Tan, 2009). However, the Interaction Analysis Model lacks breadth of analysis because it does not have a way of accounting for the social aspect of knowledge construction that could be obtained using other methods, for example by graphing interaction patterns.

Other researchers have continued to study construction of knowledge in online discussion forums with a clear tendency to mix and/or supplement qualitative analysis with other methods such as SNA (e.g., Cardak, 2016; Davis and Marone, 2016; Gunawardena et al. 2016; Jo, Park, and Lee, 2017; and Tirado, Maraver, Hernando, and Harris, 2016). These studies are introduced here briefly, but they are discussed later in this chapter under the social construction of knowledge and culture section.

Researchers who applied SNA to online discussion forums validated its adequacy to a certain extent (e.g., Dawson, Bakharia, Lockyer, and Heathcote, 2011; and Dawson, Bakharia, and Heathcote, 2010) because they only focused on information flow, describing student centrality and providing diagrams of interaction patterns, but without looking into the characteristics of posts. More recently, Jo et al (2017) revamped this approach by incorporating a qualitative analysis that looks specifically into social construction of knowledge.

There are still a few researchers such as Cardak (2016) and Gunawardena et al. (2016), who have applied mixed methods to study knowledge in online discussion forums, in which graduate students participated. The first report pertains to the Turkish sociocultural

context, including the examination of transcripts in the Turkish language, while the second to a university in the southwest of the U.S.A.

In this vein, the purpose of this study was to identify student-to-student interaction patterns by analyzing discussion forum posts, measuring student centrality, and generating social network diagrams in order to explain characteristics of posts that contribute to social construction of knowledge at the graduate level in a different sociocultural context.

To achieve the purpose of the study, the following research questions were created to address the problem statement:

1. How does social construction of knowledge relate to student centrality as defined by SNA in Spanish online discussion forums conducted in Mexico?

1a. Does knowledge construction occur through student-to-student interaction in online discussion forums as measured by the Interaction Analysis Model?

1b. What are the characteristics of the social network created by students in an online discussion forum?

1c. What are the characteristics of posts published by students with high centrality?

1d. Does higher student centrality contribute to a higher level of social construction of knowledge?

This study was aimed at informing online distance education scholars and researchers about the characteristics of discussion posts and the degree of student centrality associated with interaction sequences to high levels of social construction of knowledge. Thus, the researcher presents some reflections on the design of online discussion forums. Interaction patterns suggest an apparent positive relationship between high student centrality and high levels of social construction of knowledge may exist, furthermore dissonance in student-to-

student interaction may also contribute to the achievement of more complex phases of social construction of knowledge.

It is very apparent for the researcher that an appropriate discussion forum is one that aligns with student learning outcomes also known as course goals/objectives, as well as, week/module specific learning objectives. It is also apparent that some course objectives do not require a discussion forum designed to foster interaction that leads to high levels of social construction of knowledge, but when they do, the most appropriate way to orchestrate discussion must be commensurate with the time and effort that students need to invest to earn a grade or points, if any were allocated by the instructor.

Findings of Social Construction of Knowledge and Social Networks

Knowledge construction occurred indeed through student-to-student interaction as evidenced by results of the three forums. For example, there were a total of 24 occurrences in forum 1, 36 in forum 2, and 33 in forum 3, that is a total of 93 occurrences. The Interaction Analysis Model remained consistent as the two coders applied it to transcripts in Spanish in three different non-structured discussion forums. The dataset consisted of three archived non-structured discussion forums from an online graduate course. All forums were initiated by students and only had student-to-student interaction, i.e., they were open ended and student-centered.

Forty-six out of 93 (49.46%) occurrences, were coded as phase I, which is the beginning of the process. 18 out of 93 (19.35%) were coded as phase II, which is the level where students experience the discovery and exploration of dissonance or inconsistency among ideas, concepts or statements.

Twenty out of 93 (21.50%) were coded as phase III, which was arbitrarily set by the researcher as the threshold of high level occurrences of social construction of knowledge because it is the one phase where students experience negotiation of meaning or co-construction of knowledge. 9 out of 93 (9.67%) were coded as phase IV, where students test tentative constructions of knowledge. None of the posts were coded as phase V, which is the highest level, where students acknowledge the application of new knowledge.

The most obvious characteristic of the three discussion forums in social network terms was a very low density. The researcher identified 4 students with high centrality per forum in average. Across the three forums, there were 4 students with high centrality.

Student centrality proved to be a concept that accounts for the social aspect of knowledge construction in that centrality measures serve not only as an indicator of student overall degree of centrality, but when considered separately, centrality measures account for student prestige (in-degree), influence (out-degree), and potential access to information as it flows through a discussion forum network (betweenness centrality), therefore it was appropriate to follow SNA principles by focusing on information flow ties, as opposed to student attributes, and on networks as opposed to the entire group of students.

The holistic measure known as density, which has a value from 0.0 to 1.0, quantifies how well-connected a social network is, was less informative to explain interaction patterns. For instance, an introductions discussion forum where everybody interacts with everybody else will have high density—more so with a large amount of posts and replies—but that does not mean students are contributing to high levels of social construction of knowledge.

In this study forum 1 had a density score of 0.05, forum 2 a score of 0.14, and forum 3 a score of 0.06, i.e., all forums had a very low density score because student participation was limited to one or two posts, but there was evidence knowledge construction.

SNA, proved to be useful to quantify the prestige or influence of individual students in spite of examining discussion forums that exhibited minimal student-to-student interaction. To be more specific, student centrality measure scores were useful to explain student centrality on an individual basis after they were sorted in descending order, first by in-degree to identify "prestigious" students, second by out-degree to identify "influential" students, and third by betweenness centrality to identify "information broker" students with more potential access to information.

The betweenness centrality score was used to identify the most central student in a discussion when students were tied in second or third place of prestige or influence. This was the case in forum 2 and 3 even though all students who participated in these two forums limited their participation to a one-time post or reply. However, from a practical point of view, there is another possible explanation for the idea of potential access to information based on the typical settings instructors use across LMSs, which allow students to join a discussion at any time, therefore it would be fair to say that the student who joins a discussion at the end could have more potential access to information.

It is worth considering that from a SNA perspective betweenness (the number of shortest paths from all students to all others that pass through that student) not only can be calculated with datasets as small as the one in this study but it connotes the position of a student in the social network that emerges from a discussion forum, while a practical explanation denotes a literal interpretation of the idea of potential access to information.

Furthermore, from a SNA perspective the rationale behind betweenness implies potential access to information as it flows through the social network, while a literal explanation of access to information suggests access to information after it has already flowed through the network, which could be minutes, hours, or days after the discussion took place.

The researcher does not find the aforementioned explanations of potential access to information mutually exclusive as they seem to provide different angles that are equally informative.

The characteristics of posts published by students turned out to be evidence of a counter example of "the best way" to orchestrate online discussion forums because the instructor put all the responsibility of the discussion forums on the student shoulders and provided little to no guidance in terms of expectations.

Some of the characteristics of the posts published by the 4 students with high centrality across the three forums were: 1) Posts tend to reach multiple phases and often these students skip a phase, 2) Phase IV is the highest phase contained in their posts, and 3) Participation was limited to 1 post. It was apparent for the researcher that other characteristics of these posts may have been related to the Spanish language itself or to the Mexican sociocultural context as there was tentative language in the transcripts that suggests students used it to posit questions or ideas in an indirect manner by using the personal pronoun "we" or the possessive pronoun "our." Another characteristic that suggests the possibility of students displaying low agency in the transcripts was the constant utilization of passive voice, which generally speaking, distracts readers because passive sentences lack explicit reference to the subject/person who carries out the action/verb.

Participants in this study might have used passive voice because they consider it more "academic" or "scientific" as it is found in research or theoretical papers in places where the author needs to make emphasis on phenomena or concepts, as opposed to a subject/person. Therefore, students might have been attempting to sound more "academic" or "scientific" in their posts and at the same time avoiding making a statement or adopting a view, which could potentially lead them to argumentation.

Another characteristic of posts that could be related to the Spanish language or the Mexican sociocultural context is the use of an indirect writing style, i.e., students showed a tendency to structure their posts starting with the specifics or as people say colloquially "going off the branches," and transitioning to a more general idea before making a straightforward point.

A characteristic that was not present in the transcripts in spite of the academic setting of the three forums was the use of the more formal pronoun *usted* in Spanish in the Mexican sociocultural context, which is typically used in formal interactions with others, especially to show respect due to authority, age, or mere unfamiliarity with the person, which made sense culturally speaking because only student-to-student interaction happened in the three forums, so in a broad sense interaction happened among equal classmates.

For example in forum 1, student S21, published post number 2, writing "*I think what is complex in the assessment of an audio conference is that, even though learning is the ultimate goal **we cannot only assess learning**, but its pedagogical design and the channel, which is why I think a good start to prevent errors is to create a "checklist..."*"

In forum 2, student S16 published post number 9.1 in reply to student S03 writing "*hello everybody. When I reviewed each of your interventions, I concur with your*

*contributions, specially on the importance logistics have in an educational video conferencing session, because when this part is resolved, **we will be able to focus our attention precisely on meeting the objectives we are really interested in this type of session, as opposed to being distracted with audio, video, and connectivity problems.**"*

In forum 3, student S04, published post number 10 writing "*I did not have experiences with video Conferencing per se. **It would have been a solution for a time in which I worked from home though...**"*

To illustrate the general experience students went through in all discussion forums, it is as if the instructor of a face-to-face course told her students she has a whole class voluntary discussion learning activity, which any student can initiate. This hypothetical instructor gives the students a topic and a time limit, she walks out of the classroom and comes back when time is up, hoping students engaged in the process of social construction of knowledge.

To study social construction of knowledge and social networks, the researcher incorporated three recommendations by following Aviv et al.'s (2003) suggestion to focus on the position of a student in the social network that emerges from a discussion forum, as opposed to focusing only on the number of posts. The researcher also considered the work of Li (2009), who studied the relationship between the centrality of particular concepts and student centrality, and Buraphadeja's (2010) attempt to correlate the Interaction Analysis Model's phases and social network analysis centrality measures.

The researcher of this study addressed Aviv et al.'s (2003) suggestion to conduct further research by using SNA to reveal network structures through social network diagrams, which in turn revealed interaction sequences to high level occurrences of social construction

of knowledge. Thus, he used of the Interaction Analysis Model and Social Network Analysis in a similar way than Aviv et al. (2003), who analyzed data from a formal, structured, closed forum *vis-à-vis* an informal, non-structured, open forum. Aviv et al. (2003) found that in the structured forum, the knowledge construction process reached a very high phase of critical thinking and developed cohesive cliques, in addition the students took on bridging of information and interaction triggering roles, while the instructor had relatively little involvement.

In the non-structured forum (without an instructor's prompt and grading rubric), knowledge construction stayed at the beginning of the process, few cliques were constructed, most of the students took on the passive role of teacher-followers, and the instructor was at the center of activity. These differences were reported as statistically significant, which suggests that a well-designed forum develops significant, distinct cohesion, and role and power structures lead the knowledge construction process to complex phases of knowledge construction.

There are a couple of takeaways from Aviv et al.'s (2003) study that can be compared with the findings of this study, namely the importance of students who took on bridging of information and interaction triggering roles, and cohesiveness. When Aviv et al. (2003) refer to bridging and triggering roles, they mean the degree of student centrality and when they refer to cohesiveness, they mean density as defined by SNA.

Evidence of interaction sequences to high level occurrences of social construction of knowledge presented in chapter four appears to validate Aviv et al.'s (2003) takeaways mentioned above. First, students with high centrality who take on bridging of information and interaction triggering roles are important because they contribute positively to the

knowledge construction process. Second, a discussion forum with high density (cohesive or well-connected) fosters interaction, but a dense interaction will be beneficial for students only if it is purposefully designed to achieve complex phases of knowledge construction. Aviv et al. (2003) note that "cohesion could have both a beneficial or debilitating influence on discourse and reflection. Too cohesive a group could stifle criticism and, therefore, open discourse." They ponder "What is the optimal degree of cohesion? How should the cohesion be 'tuned'?" (p. 16).

The answer to these questions lies on the student learning outcomes/course objectives, specific learning objectives, and on students being appropriately assessed and rewarded. As a learning activity, a discussion forum is a means to an end, thus the optimal degree of density in a forum can be tuned by implementing instructional design elements such as clear instructions that help the instructor to set clear expectations, as well as guidance through grading rubrics and/or examples. Therefore, the optimal degree of density is one that is commensurate with the time, effort, points/grade students expect in order to achieve a course objective.

The researcher also addressed Li's (2009) suggestion to conduct further research by employing SNA to explore the emergence of communication patterns and structures in student-to-student online interaction. To be more specific, this research project broadened the application of SNA to online discussion forums through the successful identification of student centrality indicators, such as prestige (in-degree), influence (out-degree), and potential access to information (betweenness centrality), as useful indicators of communication patterns, in addition to social network diagrams that illustrate structures in student-to-student online interaction.

A positive relationship between higher student centrality and high levels of social construction of knowledge might exist. This observation prompted the researcher to take an extra step to verify the extent to which centrality measures explain the variability of the social construction of knowledge level through a multiple regression, which yielded statistically significant results for forum 2, which confirms to some extent Li's (2009) findings: students with high centrality contributing positively to discussion forums with ideas that become central to the discussion, and students post at different levels of social construction of knowledge across forums, which seems to happen randomly in non-structured forums.

The aforementioned observation lends support to Li's (2009) suggestion for researchers to explore student-to-student online interaction by incorporating multiple analysis techniques in order to achieve both theoretically and empirically sound results as demonstrated by Gunawardena et al. (2016), who extended the Interaction Analysis Model beyond its typical capacity of focusing on cognitive processes by supplementing it with learning analytics, and social network analysis.

Buraphadeja (2010) ran a statistical test to identify the nature of the relationship between content analysis codes and SNA centrality measures and found "the absence of a [co] relationship was found under conditions where discussion was an activity designed for individual responses rather than interaction among participants" (p. 131). Instructional design has an impact on online discussion forums in terms of social construction of knowledge, highlighting the need for online instructors to implement a combination of instructional design elements such as grading rubrics, assigning roles to students, defining the duration

and frequency of interaction, as well as the possibility of using group discussion (Buraphadeja, 2010).

The researcher's point of view, based on the data of this study is that in essence, instructional design elements certainly can help online instructors to find a balance between a structured discussion forum and flexible constructivist principles such student-centered interaction.

Validity and Trustworthiness

Results from forum 3, show an intercoder reliability level of Percent Agreement=70%, which can be considered a low level based on a conservative interpretation of Holsti's Percent Agreement as suggested by Mao (2017). It is worth mentioning here that other researchers like Tan et al. (2008) used the same model along with Holsti's Percent Agreement and reported the same Percent Agreement=70%, while Chai and Tan (2009) reported a Percent Agreement=78%. This confirms Lucas et al.'s (2014) meta-analysis, in which they reported their results were "quite similar to the results obtained in the original study [Gunawardena et al. (1997)]: there are low levels of complex thinking as the majority of operations coded remained in PhI. There is some evidence of operations in PhII and III, but they are almost non-existent in PhIV and V."

In this study, the three forums showed evidence of social construction of knowledge even though the majority of the interaction took place in phase I. While the first forum showed an absence of dissonance, the second and the third forum did not. This brings into question Lopez's (2004) finding that dissonance was not evident in discussion forums in Spanish within the Mexican sociocultural context. Lopez (2004) attributed his finding of students making a leap from lower phases of social construction of knowledge to higher

phases, without passing through intermediate phases to a cultural factor, which had to do with the absence of dissonance/phase II as open disagreement with ideas expressed by others might not to be appropriate or at least not a necessary element in the Mexican sociocultural context.

The results of this study are inconclusive on this aspect because on the one hand Lopez's (2004) finding can be confirmed in forum 1, but not in the other two forums as dissonance (phase II) accounted for 19.35% of occurrences in forums 2 and 3 combined, where students did not skip phases.

It is apparent to the researcher that dissonance has implications for the social construction of knowledge process, so it is worth highlighting the multiple regression findings. In forum 1, where there was a lack of dissonance, the multiple regression model explains 14% of the Interaction Analysis Model's phases variability, and the test was not statistically significant.

In forum 2, the multiple regression model, specifically in-degree predicts 63% of the Interaction Analysis Model's phases variability, and the test was statistically significant. This forum showed the most occurrence of dissonance of all forums with 31% of its posts coded as phase II, but there was only one post coded as phase IV.

In forum 3 the multiple regression model predicts 11% of the Interaction Analysis Model's phases variability, and the test was not statistically significant. Interestingly, forum 3 showed the most occurrence of testing tentative constructions of knowledge of all forums with 24% of its posts coded as phase IV, which speaks to the ability of students to reach complex phases either by skipping dissonance or by engaging in it moderately, which might be more appropriate in certain sociocultural contexts like the Mexican one. Furthermore, the

aforementioned findings speak to the importance of looking at social construction of knowledge from different angles that supplement qualitative analysis.

Social Construction of Knowledge and Culture

Students from the Mexican sociocultural contexts might be showing similar traits than Asian students, who find an online discussion forum designed to foster argumentation uncomfortable, and this discomfort in turn might be intensified online due to the lack of body language and verbal cues. Thus, students from Asian countries tend to build consensus—gain knowledge by accumulation—if they have to face opposing points of view in their effort to find the extent to which they can support the opposing point of view, as suggested in the discussion of the sociocultural context of a Sri Lankan and U.S. American case-based reasoning study (Gunawardena and Jayatilleke, 2014).

Gunawardena et al. (2014) explored the cultural context and the significance of dissonance and examined studies that shed light on this issue (Biesenbach-Lucas, 2003; Gunawardena, Skinner, Richmond, Linder-Van Berschot, LaPointe, Barrett, and Padmaperuma, 2008; and Nisbett, 2003). Citing the work of Bisenbach-Lucas (2003) Gunawardena et al. (2014) discuss the differences in perceptions of online discussions between native and nonnative speakers of English students, which reported that both types of students showed a tendency to avoid "challenge and explain cycles" where they had to do more than demonstrate knowledge. The survey employed in Bisenbach-Lucas' (2003) revealed that nonnative speakers, particularly Asian students, consider it far less appropriate to challenge and criticize the ideas of others, in addition to not knowing how to express disagreement appropriately in English.

Similar findings on the absence of dissonance in online discussions have been reported by Wegerif's (1998), and Curtis and Lawson's (2001), who suggested it could be attributed to a culturally induced reluctance to argue. Biesenbach-Lucas (2003) highlighted that this absence of dissonance is worrisome, as it is the "resolution of such areas of agreement and disagreement that 'results in higher forms of reasoning' because 'cognitive development requires that individuals encounter others who contradict their own intuitively derived ideas'" (p. 37).

This view was supported by Jonassen and Kim (2010), who stated "meaningful learning requires deep engagement with ideas. Deep engagement is supported by the critical thinking skill of argumentation. Learning to argue represents an important way of thinking that facilitates conceptual change and is essential for problem solving" (p. 439).

Contrary to this view, Bender (2003) suggests the possibility that "students gain knowledge by accumulation instead of by argumentation" (p. 70), which might be the case of other sociocultural contexts, as the Mexican students in this study skipped argumentation in the process of knowledge construction in forum 1 in favor of the collectivist trait of gaining knowledge by accumulation.

In a study that applied the Interaction Analysis Model to examine social construction of knowledge in online discussions between mentors from the USA and Sri Lankan mentees, Gunawardena, et al. (2008), as cited by Gunawardena et al. (2014), found that the Sri Lankan participants skipped dissonance and moved to negotiation/co-construction of new knowledge (phase III) based on consensus building. Thus, Gunawardenda et al. (2008) had to redefined dissonance as specified in the Interaction Analisis Model in cultural terms as the Sri Lankan participants were often very polite and indirect when posting a different point of view. This

team of researchers also found that even though the discussion was very polite and there was an absence of dissonance, strong opinions and disagreements were expressed by the same participants in another informal forum named "virtual café," where participants interacted in a heated debate about gender issues.

This observation led Gunawardena et al. (2008) to reflect on the role of culture in academic online discussions because it might be possible that collectivist traits in both the Sri Lankan and Mexican sociocultural contexts may have transferred to online interaction, particularly when the instructor is present. To what degree can teaching presence hinder online interaction in specific sociocultural contexts? This is a question that begs to be answered.

An example of the difference between Western and Asian worldviews is the Aristotelian tradition that continues in the West and the Confucian tradition that continues in the East. Nisbett (2003) propounds the view that Easterners "when confronted with a conflict of views, they might be oriented toward resolving the contradiction, transcending it, or finding a 'Middle way'" (p. 37), whereas Westerners are more inclined to insist on the correctness of one belief versus another as cited by Gunawardena et al. (2014).

The cultural aspect makes it necessary to discuss social construction of knowledge in relation to the instructional design of the forums, specifically to instructional design elements such as instructions, alignment of materials with course objectives, type of interaction (whole class vs group discussion), and assessment and instructor's feedback. Instructional design elements can help online instructors to provide students with conditions beneficial to student-to-student interaction even in non-structured or discussion forums where participation is voluntary.

For example, to address the need for online instructors and instructional designers to incorporate constructivist elements in a forum, an online instructor can ask individual students to take on roles such as moderator, "devil's advocate" or synthesizer as suggested by Wise, Marbouti, Hsiao, and Hausknecht (2012), and Wise, Saghafian, and Padmanabhan (2012), who examined interaction patterns resulting from assigned student roles in online discussion forums.

In both studies, Wise et al. (2012) put forward the concept of Online Listening Behaviors as distinct from prior notions of lurking in discussion forums and unveiled student perspectives on factors that influence participation. Another example of the incorporation of constructivist elements in a discussion forum would be, to divide students into smaller groups. Whether the technique of assigning roles to students is applied to group discussions or whole class discussions, it is only one possible solution that can help online instructors ensure that different elements of student-to-student interaction such as dissonance or high centrality are present, in addition to giving individual students rights and responsibilities that encourage them to interact with the group as reported by Wise et al. (2012).

The point is, online interaction in the context of an online course is meaningful and useful insofar it is seen as a means to an end, i.e., a means toward social construction of knowledge. Wise et al. (2012), lend support to this point, suggesting to continue investigation on interaction patterns through the application of SNA, and on measures of learning through the application of methods such as Gunawardena et al.'s (1997) Interaction Analysis Model to examine the characteristics of posts.

A team of researchers employed the Interaction Analysis Model along with learning analytics and SNA to study social construction of knowledge in online discussion forums by

examining a data set of 42 postings generated by 15 graduate students who discussed the topic of culture in a course about eLearning. This team, reported that knowledge construction did not exceed phase III, meaning that while the process of knowledge construction got started and moved forward to phases II and III, there was no evidence of students acknowledging they had experience complex phases that involve testing tentative constructions, or application of new knowledge (Gunawardena et al., 2016). The team observed that knowledge construction may not be purely a cognitive process, but one that is also emotionally loaded and situated within a social context.

In a study on 14 graduate students' interaction in online discussion forums of a course about the teaching profession in Turkey, in which Cardak (2016) examined transcripts in the Turkish language and followed up with students through interviews, the study showed that posts did not reveal higher levels of knowledge construction according to the Interaction Analysis Model in spite of students having a positive view of the different modes of interaction (student-to-student, student-to-instructor, student-to-content) experienced in the course. On the one hand, when students decided to participate in discussion, they preferred to reply to the moderator, on the other hand these discussion forums were not structured as a debate. For future studies, Cardak (2016) suggests that if an online discussion is not structured as a debate, more controversial topics could be selected in order to facilitate argumentation. Another reason of low level of knowledge construction might be the moderator's facilitating ability.

Another team of researchers took a similar angle to approach knowledge construction in online discussion forums. Three coders applied content analysis to a vast dataset of posts in the Spanish language relying on Garrison et al.'s (2000) CoI. This dataset of 9,878 posts

from 96 different online discussion forums that spanned three academic years, was generated by 212 college students from 9 different universities in the Spanish sociocultural context. This team found sufficient evidence to affirm that the discussion forum requirements determine the degree of social and cognitive presence observed in students, i.e., the more complex the task in terms of learning objectives, instructions, and collaboration requirements, the higher the level of cognitive and social participation (Tirado et al., 2016).

A case study in the South Korean sociocultural context employed a combination of web log mining, SNA, and content analysis to examine a variety of interaction patterns including student-to-student interaction of 43 undergraduate students who participated in an online discussion forum for 12 weeks. Jo et al. (2017) ran multiple regression analyses to predict final grades and found that the results of student-to-student interaction analysis showed that in-degree and out-degree predicted final grades, which "calls for systematic research to identify the variables that explain the quality of forum discussion activity and compare the relative importance and usefulness of discussion-related variables."

Along these lines, this study contributed to new knowledge about social construction of knowledge by explaining its relationship with student centrality and at the same time it advanced previous reports by Aviv, Erlich, Ravid, and Geva (2003), Li (2009), and Buraphadeja (2010) not only by accounting for the social aspect of knowledge construction in social network terms, but by examining data from a graduate level online course's discussion forums carried out in Spanish within the Mexican sociocultural context.

Implications

The researcher learned from the literature review that Social Constructivism is a concept that derives from Social Learning and Constructivism. On the one hand, knowledge

has social origins and is influenced by the social context in which it occurs (Bruner, 1960; Vygotsky, 1997). On the other hand, knowledge is constructed under conditions such as complex and relevant learning environments, social negotiation, multiple perspectives, ownership in learning, and self-awareness of knowledge construction (Duffy and Cunningham, 1996; Jonassen, 1997; Perkins, 1992; and Glasersfeld, 1989), but it is ultimately internalized by the individual.

Online discussion forums lend themselves well to social construction of knowledge aimed to help students achieve course objectives or specific learning objectives that involve reasoning, critical thinking, understanding and use of knowledge, self-regulation, and mindful reflection through student-to-student interaction, if they are designed appropriately to address this. Therefore, a social constructivist design of discussion forums requires a degree of complexity that provides students not only with a communication tool to interact, but with a variety of opportunities to contribute positively to interaction and a purpose, because to have discussion for discussion's sake is not an appropriate educational experience. The researcher's advice for designing forums is described in detail in this chapter under the reflections on instructional design section.

In this vein, the Interaction Analysis Model remains useful as a qualitative technique to assess social construction of knowledge by examining communication transcripts, still it is a subjective approach that can be supplemented with other methods like SNA. Like other quantitative methods, SNA is an approach that is limited in its understanding of the context in which people interact, but it has the advantage of having a myriad of resources for researchers to analyze social networks without forcing them to impose preconceived notions to data.

Social network analysts must think carefully about the kinds of networks and relations they will study before collecting data because SNA offers a point of view, but it does not predict what researchers will observe. Furthermore, SNA does not provide a set of premises from which hypotheses or predictions should be derived as suggested by Carrington and Scott (2011).

The results of this study suggest centrality measures such as in-degree, out-degree, and betweenness centrality are sound indicators of a student's overall degree of centrality. When considered separately, these measures are indicators of prestige, influence, and potential access to information, correspondingly. Centrality measures are based on the way students transmit information through the social network that emerges from a discussion forum as demonstrated by Gunawardena et al. (2016). In turn, the overall degree of student centrality can be connected to interaction sequences to high levels of social construction of knowledge. Thus, interaction itself is the epistemological foundation that makes it possible to use the Interaction Analysis Model in combination with SNA because, even though both methods are rooted in different views, they can be used to approach knowledge construction by analyzing interaction patterns of both independent relations as well as the totality of interconnected relations.

A mixed methods approach to study social construction of knowledge and student centrality in discussion forums seems appropriate because textual information such as quotes or coding examples may not be enough for a certain audience to explain the knowledge construction process in a more concrete manner and vice versa. In that, the methodology used by the researcher encouraged him to use multiple views rather than the typical association of certain perspectives for quantitative researchers and others for qualitative researchers. For

example, while the Interaction Analysis Model is rooted in a theoretical framework based on social constructivism, SNA is rooted in sociology and social psychology, therefore in the context of this study, social interaction matters because it is a function of social construction of knowledge.

The design of this research project is reflective of the researcher's constructive perspective, which implies particular ways to make sense of how humans construct knowledge through interaction, in this case, through student-to-student interaction in online discussion forums. Thus, it can be said that students construct knowledge as they engage with the world they are interpreting, and they engage with their world and make sense of it based on their historical and social perspectives. Furthermore, the most fundamental construction of knowledge is always social, arising in and out of interaction with a human group.

The basic premise of social construction of knowledge shares certain elements with Moore's (2013) seminal idea of modes of interaction, namely: student-to-teacher interaction, student-to-student interaction, and student-to-content interaction. Moore (2013) put forward the idea of transactional distance, describing it as a psychological and communication space to be crossed, a space of potential misunderstanding between the inputs of the instructor and those of the learner.

According to this idea, when dialogue is high, the transactional distance is understood to be low. Literature pertaining to transactional distance and constructivist pedagogy (e.g. Farquhar, 2013) converges on the issue of dialogue, describing it as a positive element in the teaching-learning transaction, therefore, without a capable facilitator—whether it is a central student or the instructor—working to ensure that opportunities for dialogue are being

maximized, interaction can falter, fatigue, and fail, which is true both for online and face-to-face learning environments.

Reflections on the Research Process

The Interaction Analysis Model's phases or coding categories were indeed applicable to the discussion forum transcripts in Spanish, which confirms the model's flexibility that has been appealing to many researchers who need to characterize posts that contribute or lead to higher levels of social construction of knowledge in discussion forums.

One of the limitations of this study was the lack of access to other sources of data, such as deliverables, tests, or journal entries, to mention a few examples, which limited the scope of the researcher to the analysis of transcripts. The research design did not require to ask follow up questions to any of the 21 participants or the graduate program staff or faculty, or other type of documents, so in a way it would be fair to say it was a specialized analysis that yielded a very specific answer to the research problem.

The dataset was generated in the second largest public university in Mexico, which has been actively promoting an institutional process of internationalization of its academic programs to such extent that graduate degrees are seamlessly compatible and recognized by most European and north American universities. Thus, online faculty orchestrate discussion forums similar to most western or European universities aiming to neutralize cultural factors, so culture seemed to be an emerging factor during the analysis phase indeed, but certainly not a factor that will take precedent over the importance of the essence and dynamics of online discussion forums patterns of interaction resulting from an instructional design.

Results should have a degree of transferability to similar contexts and settings. The sample size was the result of purposeful sampling, as explained in the methodology chapter.

The rationale behind purposeful sampling was to select a set of participants that represented a typical case and it was not intended to make generalizations, which requires random sampling or selecting a large number of participants, as typically found in quantitative studies. Sample sizes are typically smaller in qualitative research, but sample sizes that are too small cannot adequately support claims of having achieved valid conclusions and sample sizes that are too large do not permit the deep, naturalistic, and inductive analysis that defines qualitative inquiry. Therefore, a sample size of 21 participants was a sound number that addressed the researcher's need to reach middle ground through mixed methods.

Principles that guide SNA also limited the scope of the study in the sense the researcher had to follow certain principles to explain social construction of knowledge in social network terms. Again, he looked at relational data such as a social relation-information flow, not attributes of people such as age or income, in that, he used the social network approach to examine networks within a group of people not the group of people as a whole, which allowed the researcher to make sense of people's centrality within networks, but not of people's centrality within the group. For example there were three social networks within the selected group of graduate students because there were three discussion forums in the dataset, therefore students may have had different centrality across the three forums and it is not appropriate to attribute an overall measure of centrality within the group.

The characteristics of posts published by students with high centrality can be explained in social construction of knowledge terms by creating basic tables with centrality measures that show students with high centrality along with the phase their post or reply reached. Another part of the explanation to the characteristics of posts published by students with high centrality can be provided by creating basic tables that show those students with

high centrality along with their post number to show a glimpse of the interaction sequence next to the phase(s) their post or reply reached, including a column with an excerpt of the post or reply.

Furthermore, the researcher examined relations in a relational context, meaning he examined interaction patterns of a social network, not just relations between pairs or triads, which allowed the researcher to account for the broader patterns of ties within the network to address the totality of interconnected relations that emerge from online interaction in a discussion forum. This strategy limited the study in that the researcher had to operationalize social networks in a very specific way—carefully selected from a myriad of possibilities available to researchers—that addressed the phenomenon appropriately *vis-à-vis* the Interaction Analysis Model. The researcher operationalized social networks by focusing on whole networks, as opposed to ego networks, and on one-mode data, as opposed to two-mode data, and on directed ties.

Reflections on Instructional Design

As a technology-enhanced environment, online discussion forums are a building block for online instructors and instructional designers, who are constantly bridging the gap between learning theories and LMSs. On the one hand, learning theories may require complex processes that cannot be carried out due to technological limitations. On the other hand, powerful technologies available in LMSs are often underused as a result of too basic course objectives and/or specific learning objectives, as suggested by Lowyck (2014), who states

Both learning theories and technology are empty concepts when not connected to actors, such as instructional designers, teachers, and learners...Instructional design as

a connecting field mediates between knowing [w]hat and knowing how. Strange enough, learning theories and technology become disconnected if instructional design does not consider evolutions in learning theories. (p. 15-16).

The researcher strongly agrees with Buraphadeja's (2010) proposition of potential paths to higher levels of knowledge construction in online discussions, which is revisited in Figure 15. This flow chart suggests four instructional elements that hold true to this day for the design of online discussion, namely: role assignment, concise and controversial discussion topic, rubric with collaborative components, and reflective components.

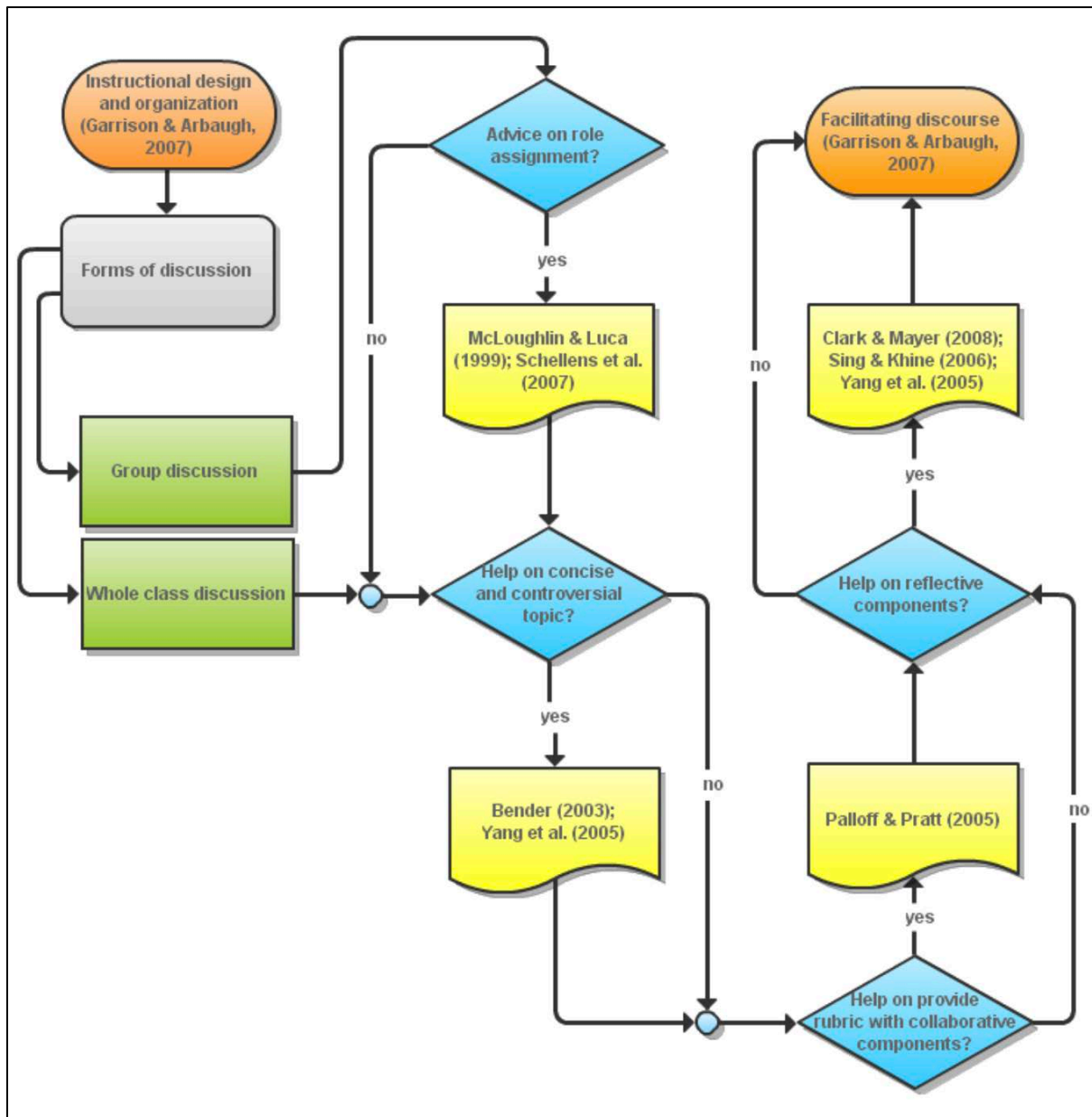


Figure 15 Potential Paths to Higher Levels of Knowledge Construction by Buraphadeja (2010)

Instructors who need to make a decision on role assignment in group discussion can apply, according to Figure 13, strategies such as student-centered interaction by requiring students to take on specific roles like leader, questioner, and summarizer with the caveat that students might cease to engage in interaction once they complete their roles (McLoughlin and Luca, 1999). A similar strategy is the scripting of the discussion by requiring students to take on roles of moderator, theoretician, summarizer, and source searcher as suggested by Schellens, Keer, Wever, and Valcke (2007), who found that when the assignment of roles to group members is introduced, students who assume a role of summarizer reached a significantly higher mean level of knowledge construction. The point is, that orchestrating student-centered group discussion is one instructional design solution that must involve the creation of a balanced mix of individual and group activities.

Instructors who need to make a decision on a concise and controversial topic either for a group discussion or a whole class discussion, according to Figure 13, can apply strategies such as requiring students succinct and informal postings, similar to a face-to-face discussion, perhaps by limiting the word count so that interruptions and rebuttals are common, stimulating, and expected as suggested by Bender (2003), who identified that "students gain knowledge by accumulation instead of by argumentation" (p. 70). Another strategy would be to use Socratic questioning, meaning, instead of asking whether and how much to intervene, the instructor should focus, not on giving the students information, but on how to get involved in the conversation and on challenging students with thought-provoking questions (Yang, Newby, and Bill, 2005).

Instructors who need to make a decision on providing a rubric with collaborative components, according to Figure 13, can apply strategies such as Pallof and Pratt's (2005)

strategy, who suggest providing students with a rubric as a tangible way of evaluating their own performance as well as the performance of the members of their team. They also suggest that a rubric should align with the course objectives so that the students end the course with a clear picture about their performance. A self-assessment rubric would help students to think about their contribution, allow them to regulate their performance, and encourage them to develop their work aiming to achieve higher levels of knowledge construction. Pallof and Pratt (2009), and Conrad and Donaldson (2010) offer a myriad of detailed examples on collaborative components that remain applicable.

Instructors who need to make a decision on the implementation of reflective components to online discussion, according to Figure 13, can apply strategies such as Structured Controversy, which is a proven technique from collaborative face-to-face learning. Clark and Mayer (2008) suggest the orchestration of a structured controversy, which can be done through a discussion forum or thread for that matter as a learning activity with the potential to add a twist to a traditional debate oriented forum. This activity consists of grouping students into small teams, e.g., teams of four or six students depending on the class enrollment. One half of the team either takes the pro or con position. Each half presents their argument, while the other half restates the argument. Halves then reverse roles. Later the team reconvenes and synthesizes to develop a team report from both positions. Unlike traditional debates, structured controversy allows students to move into synthesis phase, which is phase IV in the Interactional Analysis Model.

Clark and Mayer (2008) also advocate reflective discussion forums as a culminating learning activity that requires students to look in retrospect not only their learning experience

in terms of course objectives but in terms of the new knowledge they might have constructed, especially if it was constructed through social interaction.

Another strategy for the implementation of reflective components to online discussion, is the implementation of project based learning through group discussion as suggested by Sing and Khine (2006), who examined a three-phase, project-based discussion where students had to discuss theories, develop and share a deliverable, and write reflections about the experience of the discussion and the learned content. This strategy requires discussions that may span several weeks depending on the duration of the course as well as the different stages or parts the project requires. In project based learning a rule of thumb is to give students an early start, if at all possible, and as much time as the length of the course allows in order to break a project into more manageable smaller parts depending on its complexity or the logistics involved.

Generally speaking Figure 13 highlights the relevance of balance in the design of online discussion because on the one hand clear and upfront instructions accompanied by a detailed grading rubric and samples or examples of posts with the characteristics the instructor expects may help students to reach complex phases of knowledge construction, but they might force students to respond with lengthy, essay-like postings, which are not necessarily desirable in discussion because they can be excessive and not likely to be critiqued or are difficult to respond to. On the other hand, the lack of instructions, grading rubrics, and samples of posts puts all the responsibility of the discussion on the student shoulders and provides little to no guidance in terms of knowledge construction, which is too liberal of a constructivist approach.

Metacognition is another significant element that should be incorporated into the design and orchestration of online discussion as students would benefit greatly from being aware of how the process of social construction of knowledge works, for example by utilizing a grading rubric that serves as a guideline aimed at fostering rich and complex student-to-student interaction.

Table 19 shows an example of a grading rubric designed not only to address instructional design elements but to promote metacognition and knowledge construction among. In this rubric students are asked to participate in a group discussion as part of a case study group assignment. While there is not a "one size fits all" format for grading rubrics, this example considers a variety elements that set the stage for thought provoking interaction sequences, leaving enough room for flexibility by using descriptors or adjectives under the excellent level of performance such as well-developed, reflective, substantive, concise, and easy to read.

From an instructional design point of view, the disambiguation of the aforementioned descriptors or adjectives should be readily available to students before they start such an assignment in its description and instructions, which should be detailed and explicit in nature.

Table 19

Grading Rubric for Participation in Discussion forum (Pallof and Pratt, 2009)

Criteria	Unacceptable	Acceptable	Good	Excellent
Frequency	Participates not at all.	Participates one or two times on the same day.	Participates three or four times but postings not distributed throughout week.	Participates four or five times throughout the week.
Initial Assignment Posting	Posts no assignment.	Posts an adequate assignment with superficial thought and preparation; doesn't address all aspects of the task.	Posts a well-developed assignment that addresses all aspects of the task; lacks full development of concepts.	Posts a well-developed assignment that fully addresses and develops all aspects of the task.
Follow-Up Postings	Posts no follow-up responses to others.	Posts a shallow contribution to the discussion (for example, simply agrees or disagrees); does not enrich discussion.	Elaborates on an existing posting with further comment or observation.	Demonstrates analysis of others' posts; extends meaningful discussion by building on previous posts.
Content Contribution	Posts information that is off topic, incorrect, or irrelevant to the discussion.	Repeats but does not add substantive information to the discussion.	Posts information that is factually correct; lacks full development of concept or thought.	Posts a factually correct, reflective, and substantive contribution; advances discussion.
References and Support	Includes no references or supporting experience.	Uses personal experience, but no references to readings or research.	Incorporates some references from literature and personal experience.	Uses references to literature, readings, or personal experience to support comments.
Clarity and Mechanics	Posts long, unorganized, or rude content that may contain multiple errors or may be inappropriate.	Communicates in a friendly, courteous, and helpful manner, with some errors in clarity or mechanics.	Contributes valuable information to the discussion, with minor clarity or mechanics errors.	Contributes to discussion with clear, concise comments formatted in an easy-to-read style free of grammatical or spelling errors.

The aforementioned reflections point to the need for researchers to move forward studying social construction of knowledge and social networks by taking into consideration the future research ideas presented in the following pages.

Future Research

Directions for future research and practice align with the researcher's main finding: even in the presence of a minimal amount of student-to-student interaction due to the non-structured student centered nature of the forums, there is evidence of the social construction of knowledge process in all of them, but mostly at the beginning of the process, not at more complex phases of knowledge construction. Furthermore, results suggest dissonance may have a positive impact on social construction of knowledge as it seems to be an element that is present when high levels of social construction of knowledge occur.

While constructivist instructional approaches suggest giving individual students rights and responsibilities that encourage them to interact with their class mates, that does not mean the instructor is exempt from having responsibilities, as a matter of fact, from a constructivist view an instructor has to be a facilitator, which implies providing a certain degree of guidance and feedback.

Researchers need to advance the study of social construction of knowledge in online discussion forums, as it pertains to student-to-student interaction, by taking a closer look at the instructional design elements that may contribute to the occurrence of more complex phases as well as to the emergence of central students. Researchers also need to extend the study of social construction of knowledge in online discussion forums to other sociocultural contexts and/or languages to determine the extent to which the Interaction Analysis Model remains consistent.

In the application of SNA to online discussion forums, particularly when generating social network diagrams, researchers should include—at a bare minimum—the pseudonym of the post/actor (node), the interaction sequence number of the directed edge (arc), and the

phase of the post(s) to identify those posts published by students with high centrality and connect them to qualitative characteristics found in the transcripts. Supplemental qualitative information can give researchers the ability to "zoom in" on a diagram as they look for evidence of patterns that indicate whether higher student centrality contributes to a higher level of social construction of knowledge or not.

Extending the study of social construction of knowledge in online discussion forums to other sociocultural contexts and/or languages remains an avenue for researchers to explore with caution in higher education institutions with and internationalization process in place because it is probable that such an institutional effort may be having an impact on cultural factors typically involved in online student-to-student interaction.

The debate of whether Holsti's Percent Agreement statistic is too liberal to calculate intercoder reliability for methods with nominal scales such as the Interaction Analysis Model should be put to rest as there are other procedures available to researchers to incorporate the necessary scientific rigor to the study of social construction of knowledge. For instance, coders selected to perform the intercoder reliability test should be representative of the general public, they should follow clear coding instructions and conduct the coding independently. Also, coders that are more similar to each other are likely to produce a higher level of intercoder reliability.

When applying Holsti's method, a higher value should be adopted to decide whether the coding scheme is reliable as suggested by Mao (2017). In general, a Holsti's percent agreement higher than 0.9 (90%) is considered to be a high level of intercoder reliability. If the desired intercoder reliability level cannot be achieved, researchers can improve it by excluding unreliable coding items, recoding or lumping categories, or having three or more

coders code the data and discuss disagreements until they reach agreements, which is exactly what the two coders in this study did.

To advance the study of social networks created by students in online discussion forums researchers need to take a closer look at other communication tools available in LMSs because as popular as threaded discussions are in online Higher Education courses, the discussion board is only one of many tools for the creation of learning activities that involve social construction of knowledge. Other tools such as blogs, wikis, journals, groups, instant messengers, and web conferences that exist within the institutional LMS or teaching/learning information and communication tools set e.g., Office 365® also play an important role in knowledge construction and sharing.

Future studies should go beyond analyzing social construction of knowledge and social networks and examine the latter as an indicator of leadership potential, meaning the degree to which a student either receives help-seeking questions or influences other students through written online communication. Also, centrality measures should be examined in connection to student success in terms of grades.

Researchers should continue the study of social construction of knowledge and social networks in online discussion forums from different angles that include, but are not limited to explaining the student's perspective. To be more specific, researchers are encouraged to use approaches that explain the impact of online discussion display settings on the student's view, which in turn may impact the student's ability to process information.

For example, the online interaction experience can be categorized into two main setups commonly used by instructors, namely whole class discussion vs group discussion, but regardless of the setup, what is important to explore further is the impact of orchestrating

discussions either by allowing students to create their own discussion forums or by having them interact within a discussion forum created by the instructor, which consequently will have the potential to be more dense—visually speaking—as everybody will post and reply under the same thread.

Another angle is that of Wise et al.'s (2012), who have been studying the concept of online listening. Students who only do online listening in discussions are colloquially known as "lurkers." Thus, online listening is a concept that explains how students involved in online interaction attend to the ideas of others without actually engaging in discussion. Researchers can examine online listening through learning analytics by tracking the way students access and pay attention to messages posted by others to learn about different patterns and how this then impacts their subsequent contributions, if any. Identifying and characterizing concepts such as online listening may help online instructor to support their students through the process of knowledge construction, perhaps with the help of students with high centrality, for example moderators.

Generally speaking, future research efforts should revolve around the question of what is the best way to orchestrate discussion forums that lead to high levels of social construction of knowledge. This question should remain a constant reflective challenge for researchers, online instructors and students, instructional designers, and university leaders as there is not a "one size fits all" design of online discussion forums.

Conclusion

There might be a positive relationship between student centrality and the occurrence of high levels of social construction of knowledge, thus the researcher puts forward the notion that social interaction is as important as individual knowledge construction in a

discussion forum, therefore there should not be trade-off between quantity of interaction and quality of information in student lead discussion forums. This observation suggests the balance of interaction lies on the proper alignment of student learning outcomes, specific learning objectives, materials, learning activities, but most important on providing students with explicit information such as grading rubrics, examples of posts, and other resources designed to set interaction expectations before students post as well as to make the social construction of knowledge explicit in a debate oriented forum, otherwise "student's won't know what they don't know," and knowledge construction will remain a hidden esoteric goal that only exists in abstract form in the online instructor's mind.

To reiterate, dissonance may have a positive impact on social construction of knowledge as it seems to be an element that is present when high levels of social construction of knowledge occur. This is particularly important to consider as one of the values that has been at the core of the mission of western universities for centuries is the capacity of faculty to facilitate the exchange of ideas and expressions of agreement and disagreement through communication mechanisms such as online discussion forums.

It is very apparent for the researcher that "to have discussion for discussion's sake is not good instructional design. The discussions within an online distance education course must be well orchestrated to enable the learner to meet the learning outcomes, and build knowledge and insights" (Shearer, 2013, p. 257). Thus, it is important to embed a degree of complexity in the design of online discussion, regardless of the LMS and the communication tool, that allows students to get involved in interaction sequences to high levels of knowledge construction that effectively address one or more course objectives while rewarding students commensurately in exchange of the time and effort they put into such a learning activity.

Teaching presence and cognitive presence as defined by Garrison and Akyol (2013) remain significant issues that should be taken into consideration in the design and orchestration of online discussion. The first concept is understood as "the design, facilitation and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes" and the latter as "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry" (pp. 108, 110).

The researcher's finding of a possible relationship between social construction of knowledge and student centrality in discussion forums seems to align with those of researchers like Cardak (2016); Gunawardena et al. (2016); Jo et al. (2017), Tirado et al. (2016), in that in-degree and out-degree are reliable indicators of student centrality that can be associated not only with the knowledge construction process, but with other concepts such as success in terms of final grades. Furthermore, the researcher draws a parallel between the Interaction Analysis Model and Garrison and Akyol's (2013) CoI that lends support to the idea that the degree of complexity of an online discussion triggers cognitive and social processes that are much needed in Higher Education.

It is very apparent for the researcher that if something or someone causes the social network that emerges from an online discussion forum to be either well-connected or fractured impacting the relation or interaction between students, the connection or fracture matters because of the social impact it may have in terms of social construction of knowledge. This social implication is paramount, again, the exchange of ideas and expressions of agreement and disagreement, especially in writing, is a value, a skill, and an art that still is at the core of the mission of western universities.

The researcher's finding of a possible relationship between social construction of knowledge and student centrality in discussion forums lends empirical evidence to the following ideas: knowledge is constructed by students as they engage with the information they are interpreting, students engage with information and make sense of it based on their historical and social perspectives, and the basic generation of knowledge is always social, arising in and out of interaction, in the case of this study within an online graduate level course at the forefront of the efforts of the second largest public university in Mexico.

University leaders accept online distance education more than online instructors as reported by Allen and Seaman (2013), who presented their findings on tracking online distance education in the United States of America for a decade. On the one hand they found that the percentage of chief academic leaders that state online learning is critical to their long-term strategy was at 69% (the highest in decade), but 44.6% of them believe it takes more faculty time and effort to teach online. In contrast to academic leaders' position, only 30% of chief academic officers stated their faculty accept the value and legitimacy of online education.

Perhaps, these contrasting perceptions have to do more with the fact that just as online instructors and instructional designers are able to master one technology a new version comes out while there is added pressure from university leaders to enforce that any learning technology has a positive impact on students achieving learning outcomes that are objectively measurable. In the midst of the growth and development of online distance education and shrinking university budgets, the simplicity of online discussion forums remains appealing to online instructors, but its real value is its capacity to facilitate the exchange of ideas and expressions of agreement and disagreement insofar as it is

purposefully designed to foster social construction of knowledge, which is a value that has been at the core of the mission of universities for centuries.

APPENDIX**A. Interaction Sequences of All Forums**

Interaction Sequence of Forum 1

Prompt initiated by student S20: "*How can we assess whether the objective was met in an audio [web] conference? What mistakes must we avoid to reach the objectives?*"

1. S15 published this post at phase I
2. S21 posted at phase I
 - 2.1. S02 replied to S21 at phases I and III
 - 2.1.1. S19 replied to S02 at phases I and III
 - 2.2. S07 replied to S21 at phase I
3. S03 posted at phase I
 - 3.1. S16 replied to S03 at phase I
4. S10 posted at phase I
5. S08 posted at phases I and III
6. S07 posted at phases I and III
 - 6.1. S09 replied to S07 at phases I and III
7. S04 posted at phase I
8. S05 posted at phase I
9. S11 posted at phase I
10. S13 posted at phase I
11. S17 posted at phase I
 - 11.1. S12 posted at phases I and III

12. S06 posted at phase I

13. S14 posted at phase I

Interaction Sequence of Forum 2

Prompt initiated by student S19: *"My contribution is very simple, I think taking the experiences we have had in the course as a starting point, it is fundamental to have a network and technical tools that guarantee us communication. In order to use this resource for educational purposes we have to rely on adequate infrastructure and specialized technical support, even though we can use free web tools given their own limitations due to the fact they are open they cannot guarantee us planning freedom or a good coverage. Working with these tools requires one focuses too much on technical aspects that may arise during the communication, so it is possible but not ideal."*

1. S11 posted at phases I, II, and III
2. S10 posted at phases I, II, and III
3. S13 posted at phases I and III
4. S18 posted at phases I, II, and III
5. S08 posted at phases I, II, and III
6. S02 posted at phases I, II, and III
 - 6.1. S09 replied to S02 at phases I, II, and III
7. S05 posted at phases I, II, and III
8. S15 posted at phases I and II
9. S03 posted at phases I, II, and III
 - 9.1. S16 replied to S03 at phases I and II
 - 9.1.1. S12 replied to S16 at phase I
 - 9.1.1.1. S21 replied to S12 at phases I, II, III, and IV

Interaction Sequence of Forum 3

Prompt initiated by student S05: *"In 2011, I had the opportunity to work in the Pan American Games Guadalajara 2011. Before the event there were technical meetings with national Olympic committees, which presidents and their council attended, to agree upon technical issues of each discipline, assistance the entire committee would get from the host, such as: transportation, meals, lodging, laundry service, stay, etc. Some countries with limited resources, such as Saint Kitts and Nevis, Netherlands Antilles and others, could not travel to attend this meeting, as they argued their budget only allowed them to travel to the actual games, along their athletes, so it was decided to carry out informative and decision making sessions through audio [web] conference.*

Accomplishments:

- *Savings in travel per diem for national Olympic committees from each country.*
- *They were informed about the assistance they would receive and technical issues, which allowed for the meeting to move forward.*
- *They received the itinerary as well as the necessary information electronically in timely fashion.*
- *All parties involved informed their part and listened to the needs of the national Olympic committee.*
- *Connections [calls] were made in timely fashion.*
- *There were quick brakes.*
- *There were not technical problems thanks to testing the necessary equipment with the Technologies team.*

- *Technical personnel were required to attend the entire meeting.*
- *The hosting committee defined roles for the meeting participants.*

Problems:

- *Countries spoke English in a fast-paced rhythm, not all involved in the meeting were able to capture the whole message. Translating was even difficult for a professional interpreter who was present. This made the meeting slower.*
- *Sessions for information exchange were very long because the exchange of information got complicated. This made it tiring and frustrating.*
- *I did not know how they organized their headquarters in those countries, but they did not have technical problems."*

1. S15 posted at phases I, II, and IV
 - 1.1. S21 replied to S15 at phases I and II
 - 1.1.1. S09 replied to S21 at phases I and II
2. S14 posted at phases I, II and IV
3. S11 posted at phases I, II, and III
4. S08 posted at phase I
5. S17 posted at phases I and III
 - 5.1. S02 replied to student S17 at phases I, II, and IV
6. S01 posted at phase I
7. S18 posted at phase I and IV
8. S03 posted at phases I and II

9. S06 posted at phases I and IV

10. S04 posted at phases I and IV

10.1. S13 replied to S04 at phases I and IV

11. S10 posted at phases I, III, and IV

B. Multiple Linear Regression of All Forums

Multiple linear regression to predict social construction of knowledge level based on centrality measures for forum 1.

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.38
R Square	0.14
Adjusted R Square	-0.04
Standard Error	0.99
Observations	18.00

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	3.00	2.26	0.75	0.77	0.53
Residual	14.00	13.74	0.98		
Total	17.00	16.00			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	0.28	1.18	0.24	0.81	-2.24	2.81	-2.24	2.81
In-Degree	-6.05	12.61	-0.48	0.64	-33.09	20.99	-33.09	20.99
Out-Degree	1.33	1.14	1.17	0.26	-1.12	3.79	-1.12	3.79
Betweenness	0.18	0.38	0.47	0.65	-0.65	1.00	-0.65	1.00

Multiple linear regression to predict social construction of knowledge level based on centrality measures for forum 2.

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.80
R Square	0.63
Adjusted R Square	0.51
Standard Error	0.51
Observations	13.00

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	3.00	4.00	1.33	5.20	0.02
Residual	9.00	2.31	0.26		
Total	12.00	6.31			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	3.00	0.17	17.78	0.00	2.62	3.38	2.62	3.38
In-Degree	-1.67	0.71	-2.36	0.04	-3.26	-0.07	-3.26	-0.07
Out-Degree	0.00	0.00	65535.00	#NUM!	0.00	0.00	0.00	0.00
Betweenness	0.05	0.03	1.44	#NUM!	-0.03	0.12	-0.03	0.12

Multiple linear regression to predict social construction of knowledge level based on centrality measures for forum 3.

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.34
R Square	0.11
Adjusted R Square	-0.13
Standard Error	1.24
Observations	15.00

ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	3.00	2.13	0.71	0.47	0.71
Residual	11.00	16.80	1.53		
Total	14.00	18.93			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	3.00	0.37	8.05	0.00	2.18	3.82	2.18	3.82
In-Degree	-1.17	2.15	-0.54	0.60	-5.89	3.56	-5.89	3.56
Out-Degree	0.00	0.00	65535.00	#NUM!	0.00	0.00	0.00	0.00
Betweenness	0.04	0.06	0.70	#NUM!	-0.09	0.17	-0.09	0.17

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