Structural Investigation of Learning Communities in Higher Education Online Learning

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Declaration

I hereby declare that this thesis is my own work and that, to the best of my knowledge, it does not contain any unattributed material previously published or written by any other person. I also declare that the work in this thesis has not been previously submitted to any other institution for, or as part of, a degree.

This study was granted approval by Macquarie University Ethics Review Committee (Human Research) (reference: 5201600894, see Appendix C) and conducted in accordance with the guidelines stipulated. Data collection for the case study in chapter six was approved by the Educational Research Ethics Committee, Aston University.

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TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

ABBREVIATIONS & SYNONYMOUS TERMS

Abbreviation / Synonym	Term
CoIs	Communities of inquiry
CoPs	Communities of practice
CP	Cognitive presence
HEOL	Higher education online learning
LA	Learning analytics
LMS	Learning management system
LPP	Legitimate peripheral participation
Online	Virtual
Online learning	e-Learning
S	Session
SES	Socioeconomic status
SNA	Social network analysis
SP	Social presence
TP	Teaching presence
Traditional	Face-to-face, physical
ZPD	Zone of proximal development

THESIS ABSTRACT

The unprecedented growth in online learning over the past decade has led to similar unprecedented interest in online learning communities. Given their long-established pedagogical significance, learning communities in one form or another have featured prominently in the field of education. Two types have communities that have gained considerable popularity in higher education online learning (HEOL) include the *communities of practice (CoPs)* and *communities of inquiry (CoIs)* which originate from the Community of Practice and Community of Inquiry frameworks. There is no shortage of literature reporting on the myriad benefits of learning within CoPs and CoIs which are commonly used as guides for designing learning environments and as theoretical lenses for assessing pedagogical processes in the traditional, face-to-face and online learning environments. This research presents a novel approach for investigating the structure of online communities and identifying CoPs and CoIs in HEOL using social network analysis (SNA).

The CoP and CoI frameworks are contextually and conceptually distinct, the former developed specifically for online learning research and practice and the latter originating in the context of professional learning of apprentices. However, both types of communities comprise of structural and non-structural components. The structural component constitutes the interactions that take place between individuals within the community. In HEOL, these interactions typically occur within a learning management system (LMS). These interactions represent the paths or channels upon which the non-structural or qualitative components of the frameworks emerge. The proliferation of online learning has brought with it access to large amounts of data which is increasingly being used by researchers for investigating the design, cultivation, and sustainability of CoPs and CoIs in HEOL. However, a large majority of the existing research on CoPs and CoIs relies heavily on extensive and time-consuming qualitative methodologies and therefore focuses on the non-structural components of the frameworks. To date, although there is some literature that explores certain structural aspects of CoPs and CoIs, there have been no attempts at conceptualization of the holistic structure of and unique structural differences between CoPs and CoIs. Therefore, much remains to be understood with regards to the structural aspects and implications thereof of the two types of communities – a glaring gap in existing literature. Not only that, by virtue of being retrospective, qualitative research does not allow for realization of the immediate practical value of the CoP and CoI frameworks, a short-coming identified in existing literature.

Thus, pivoting on the assumption that the distinct conceptual underpinnings and somewhat different pedagogical orientations of the CoP and CoI frameworks would be reflected in the interactional or structural dynamics within the communities, this research explores if and how SNA can be applied to online data for structurally investigating and identifying CoPs and CoIs in HEOL. This thesis comprises of a total of eight chapters, five of which are stand-alone research papers, each based on a different set of data. The thesis follows a sequential mixed method approach inclusive of two exploratory systematic literature reviews, a methodological framework and multiple case studies.

- Chapter 1 presents the background for the research, the focus and overarching research questions, overall research methodology, and structure of the thesis.
- Chapter 2 further expands on the background and provides a detailed rationale for undertaking the research. Starting from a review of the history of community-based learning it discusses the pedagogical foundations of learning communities. Then, an overview of the CoP and CoI frameworks with an emphasis on the structural components of each is presented. The application of the frameworks in HEOL and lack of attention by researchers to the structural components of each is discussed. Finally, gaps identified throughout the chapter are consolidated leading to the overarching question guiding this research.
- Chapters 3 (Paper 1) and 4 (Paper 2) comprise of two systematic literature reviews which were conducted to explore previous research that integrates SNA with the CoP and CoI frameworks. The reviews were undertaken to obtain guidelines for development of a methodological framework using SNA as the key methodology for investigating and identifying CoPs and CoIs in HEOL.
- Chapter 5 (Paper 3) describes the development, application and interpretation of the Integrated Methodological Framework (IMF) for investigating and identifying CoPs and CoIs in HEOL. The paper includes a preliminary case-study on a blogging network to demonstrate the application, interpretation and effectiveness of the IMF.
- Chapter 6 (Paper 4) presents a second case-study which demonstrates the application and interpretation of the IMF which identifies a CoP within discussion forums in a course of study.

- Chapter 7 (paper 5) presents a third case study which demonstrates the application and interpretation of the IMF which identifies a CoI and a lack thereof within discussion forums in two different offerings of the same course of study.
- Chapter 8 concludes the thesis with an overview of the findings, limitations of the research, contribution to knowledge, implications of the research, and suggestions for further research.

The key contribution of this research is development of the IMF which presents a novel approach for structurally investigating and identifying CoPs and CoIs in HEOL using SNA as the key methodology. By visually conceptualizing and quantitatively evaluating CoPs and CoIs, the IMF makes a valuable contribution towards a unique understanding of learning communities from a structural perspective. By acting as a preliminary filter, the IMF reduces or perhaps even eradicates the need for extensive qualitative analysis previously required thereby allowing ongoing assessment of community formation in online learning. As a lens for making pedagogical sense of online data, as it is, the IMF holds practical implications for academics and researchers familiar with SNA who can, at a minimum, use it for conducting active research on online learning communities and potentially inform real-time intervention during online learning activities. Consequently, the IMF allows for realization of the immediate practical value of the CoP and CoI frameworks as well. With further use, testing, refinement and potential automation, the IMF presents as a tool that can be embedded within LMSs for use by the wider community of online lectures, facilitators, designers and even students aiming to capitalize on the benefits of teaching and learning within CoPs and CoIs.

THESIS FOREWORD

I am told that a PhD dissertation should read like story that takes the reader on the student's journey. Given that this a PhD by publication in which majority of the chapters are formally written research papers, I narrate the story behind each publication in the informal forewords to the chapters. This PhD is an amalgamation of my deep interest in social networks and pedagogical practices especially in the online space, interests I developed at various stages over the years and that have been brewing for a while.

I have wanted to do a PhD since as far back as I can remember. Since my bachelor's degree way back in the 1990s, when I was first introduced to network analysis, until the time I completed my master's degree in educational psychology in 2014, the sequence of events in my life could not have taken me further away from academia. At heart, I have always been a researcher which, now that I think about it, probably explains the multiple career changes that were driven by a sense of dissatisfaction, a sense of incompleteness, a void. As fate would have it, in 2016, I was presented with the opportunity to pursue my dream, a PhD. It was a now or never decision for me therefore, despite other commitments, I jumped at it. So here I am now, almost 3 years later, smiling as I write the foreword to this dissertation with a deep sense of satisfaction and accomplishment.

I hope you enjoy reading about my PhD journey as much as I have enjoyed writing about it!

1. Chapter I: Introduction

1.1 Overview

This chapter introduces the research by situating it in the context of learning communities in higher education online learning (HEOL). The background provides the impetus for undertaking the research after which the conceptual framework and over-arching research questions are presented. Then, the overall research methodology is described following which the contribution of the research to the field of online learning communities is stated. Finally, the structure of the thesis with brief explanations of the included research papers and the methodology and data used in each is provided.

1.2 Research Background

The rate of growth in online learning has reached unprecedented levels globally (Qayyum & Zawacki-Richter, 2018). In the United States, the percentage of higher education students enrolled in degree-granting institutions who took online courses increased from 25.9% in 2012, to 27.1% in 2013 and 28.3% in 2014 (Allen & Seaman, 2017). In Australia, revenue from the online industry is expected to increase at an annual rate of 0.4% up until 2018-2019 (Online Education, 2018). In China, the online education market is expected to grow 20% annually, reaching US$41 billion in 2019, up from US$23 billion in 2016 (Yu, 2018). Online learning affords (Gibson, 1979) constant connectivity irrespective of space and time thereby providing wider and richer avenues for sharing interests, resources and information, discourse, collaboration, etc. – some of the key indicators of learning communities, a construct with historically significant pedagogical implications. The proliferation of online learning has seen a parallel increase in interest in the idea of learning communities. Underpinned by socio-cultural and socio-constructivist learning perspectives, interactions between individuals within an environmental or cultural context play a critical role in pedagogical processes within learning communities. In the context of HEOL these interactions primarily occur between lecturers, tutors, students, etc. in the online space of a course within a learning management system (LMS).

The concept of community-based learning has existed in one form or another for centuries however, formal recognition of the idea in the educational context dates back to European

Universities in the 19th century (Residential Colleges, 2018, para 1). From their origin to the currently pervasive online learning communities, the value of community-based learning stands on years of research. Advocates of community-based learning refer to learning communities as the holy grail of online learning (Palloff & Pratt, 2007). The significance of interactions (also commonly termed engagement or participation) in online learning corresponds with the prominent role of interactions in learning theories grounded in the notion of learning as an inherently social process involving engagement and discourse. Therefore, it is not surprising that majority of the online learning design and facilitation models and frameworks also find their roots in socio-constructivist and socio-cultural learning traditions (Mayes & de Frietas, 2004) – pedagogies supported by learning communities. Nowadays, the term learning communities is used loosely and refers to various types of communities (Love, 2012) however, in the context of HEOL, two types of communities namely, communities of practice (CoPs) (Wenger, 1998) and communities of inquiry (CoIs) (Garrison, Anderson, & Archer, 2000) have gained substantial popularity over the past decade. The CoP and CoI frameworks are empirically tested and well-established community-based learning frameworks that have been used commonly as guides for instructional design and as theoretical lenses for investigating learning and teaching processes within online learning communities (Correia & Davis, 2008; Johnson, 2001; Nelson & Temples, 2011).

Online learning has made available large amounts of data which is increasingly being used by educational researchers to explore online learning processes including group structures like learning communities (Cela, Sicilia, & Sanchez, 2015). Coming back to CoPs and CoIs, there is abundant research reporting on the benefits of learning within CoPs and CoIs. For instance, CoIs are associated with student satisfaction (Kim, 2011), higher retention (Boston, Diaz, Gibson, Ice, Richardson & Swan, 2009), deeper learning experiences (Warner, 2016), better learning outcomes (Hwang & Arbaugh, 2006) and CoPs have been linked to a sense of ownership (Cooper, 2014; Gauthier, 2016), reflective practice (Yang, 2009), a sense of trust, connection and satisfaction (Jimenez & Olson, 2012), etc. Given the generally accepted efficacy of learning within CoPs and CoIs, it is not uncommon to find literature on guidelines specifically for designing and cultivating online CoPs and/or CoIs (e.g. Baker & Beames, 2016). Literature on the effectiveness of learning designs to create CoPs and CoIs is also available (e.g. Murad, Lederman, Bosua, Chang, & Wark, 2016; Richardson, Arbaugh, Cleveland-Innes, Ice, Swan, & Garrison, 2012). However, a large majority of the existing research on CoPs and CoIs in HEOL relies on extensive and time-

consuming qualitative methodologies applied to survey based and/or interview data or transcripts of online data from LMSs and/or other online platforms. Consequently, the research is ex post facto or retrospective. This heavy reliance on qualitative methodologies primarily rests on the historical and currently prevalent notions about CoPs and CoIs which are primarily conceived from a qualitative perspective. For instance, a CoP is characterized by shared interests, material and conceptual artefacts and reification (Wenger 1998) whereas, a CoI is distinguished by three intersecting presences, that is, social presence (SP), teaching presence (TP) and cognitive presence (CP) (Garrison, Anderson, & Archer, 2000).

At the very least, learning communities are groups of individuals with common interests who come together and share information and resources. Based on this minimalistic definition, the basic components of a learning community constitute the structure of the community, that is, the network of connections (interactions) between individuals, which can be termed as the structural component, and the non-structural component, which constitutes the qualitative aspect explained above. As mentioned earlier, much of the existing research on CoPs and CoIs has focused on the non-structural components of the frameworks. Although there is literature that explores certain structural components of CoPs and CoIs, to date, there is limited understanding of the holistic structure of and structural differences, if any, between CoPs and CoIs. As such, much remains to be explored about the overall structural dynamics of the two types of communities. Pivoting on the relationship between networks and communities (Wenger, Trayner and de Laat, 2011), social network analysis (SNA), a quantitative analytical technique, has frequently been used to explore some structural aspects of CoPs and CoIs in different contexts including education however, as discussed, existing research and knowledge and understanding of the holistic structure of CoPs and CoIs is incomplete to say the least. Most importantly, existing literature suffers from a lack of attention to the pedagogical interpretation and implications of the structure and dynamics within the two types of communities.

Briefly, SNA is a multi-disciplinary technique which examines relationships (interactions) between nodes (individuals) connected with one another in a network (Wasserman and Faust, 1994). SNA comprises of numerous constructs at the whole-network and individual node level and allows for intuitive visualizations of connections, relationships or interactions in the network down to the node level. Before going any further, it is imperative to understand the distinction and relationship between the network which underlies a community and the community. A

network is defined as, “A set of connections among people, whether or not these connections are mediated by technological networks. They use their connections and relationships as a resource in order to quickly solve problems, share knowledge, and make further connections” (Wenger, Trayner, & de Laat, 2011). On the other hand, “A community is a group of individuals identifiable by who they are in terms of how they relate to each other, their common activities and ways of thinking, and their beliefs and values” (Biza, Jaworski, & Hemmi, 2014). A network and community can be viewed as different aspects of the same social configuration (Wenger, Trayner, & de Laat, 2011). The network is the social structure underpinning the community while the community provides the social mechanism through which the learning process creates the learning experience. While a network is simply a group of entities joined together by relationships, a community takes time to form. Learning in a community is different from learning in a network. A community is characterised by a shared purpose, mutual engagement, a sense of belonging, ownership and strong ties (Wenger, 1998). On the other hand, learning in networks is classified as emergent and has been linked to chaos and complexity theory (Williams, Karousou, & Mackness, 2011, p. 41). The type and nature of connections formed in a network dictate the learning process and consequent learning experience which in turn characterize the types of communities formed. Given that SNA has been previously applied to online data and has been effective in exploring structural aspects of CoPs and CoIs by examining the networks underpinning the communities, prompted the question of whether SNA could be used as a primary technique for holistically exploring the structural components of CoPs and CoIs in HEOL. If so, would the contextual and conceptual differences between CoPs and CoIs be reflected in the structural configurations and dynamics of the networks underlying the communities?

1.3 Focus of the Thesis

This research aims to explore the viability of SNA as a technique for investigating and identifying CoPs and CoIs in HEOL based on the structural configurations and dynamics within each. Figure 1 below depicts the conceptual framework for the research, the focus of which lies at the intersection of learning communities, specifically CoPs and CoIs and SNA. The intersection represents those structural components of a CoP and CoI that would be identifiable with corresponding constructs in SNA which is applied to online interactional data from a LMS.

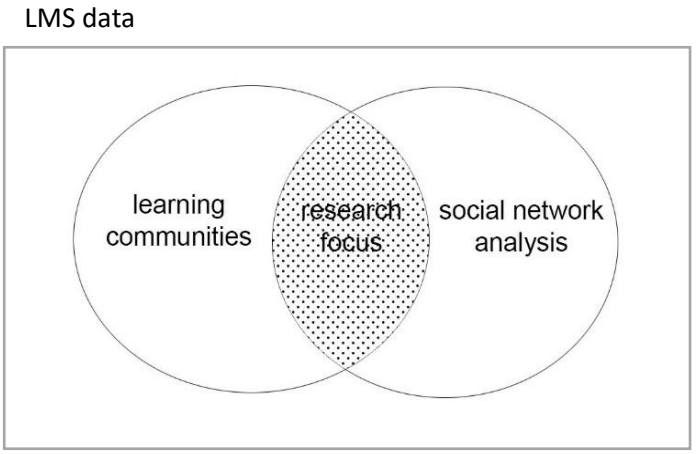

Figure 1. Conceptual framework

Thus, this research was guided by the following overarching question:

Can SNA be used as a primary methodology for structurally investigating and identifying learning communities, specifically, CoPs and CoIs, in HEOL? If so, how?

To address the overarching research question, firstly, the structural components of CoPs and CoIs were explored (Chapter 2) secondly, exploratory systematic literature reviews (Chapter 3, Paper 1 and Chapter 4, Paper 2) were conducted to scope and evaluate previous research that has integrated SNA with the CoP and CoI frameworks. Each of the literature reviews was guided by specific research questions. In general, the reviews aimed to explore:

- How has SNA has been for investigating online CoPs and CoIs?
- Which SNA constructs have been used and how?
- Which components of CoPs and CoIs have been explored by SNA?
- How effective has SNA been in exploring or evaluating online CoPs and CoIs?

Thirdly, based on the structural components identified (Chapter 2), findings from the systematic literature reviews which were consolidated, synthesized and critically evaluated (Chapter 3, Paper 1; Chapter 4, Paper 2) and additional literature (included in Chapter 5, Paper 3), a SNA based methodological framework, the Integrated Methodological Framework (IMF) (Chapter 5, Paper 3) was developed. Fourthly, the IMF was tested in three case studies on differently designed online activities in four courses. The preliminary case study (Chapter 5,

Paper 3) and two detailed case studies (Chapter 6, Paper 4 and Chapter 7, Paper 5) were each guided by specific research questions. In general, the case studies were guided by the following question:

- How does learning design influence the formation and evolution of learning communities, specifically, CoPs and CoIs, in HEOL?

The objective of the case studies was to validate the IMF as an effective framework for a structural investigation and identification of CoPs and CoIs in HEOL. The case studies and the different types of communities identified in each demonstrate the capacity of the IMF to reflect the impact of the learning design of online activities on interactional dynamics between participants and consequent community formation.

1.4 Contribution of the Research

This research fills a gap in existing literature on learning communities in HEOL by proposing the IMF as a tool for a structural investigation and identification of CoPs and CoIs using SNA as the key methodology. The IMF presents a unique approach which allows for a holistic visualization and quantification of CoPs and CoIs by contextualizing SNA constructs in structural components of the CoP and CoI frameworks. The IMF differentiates between CoPs and CoIs based on structural differences between them. The proposed framework makes a novel contribution to the field of learning communities which have previously been researched and understood primarily from a non-structural perspective. By focusing on the configuration of interactions in the learning process rather than the content of exchange, the IMF highlights the significance of "connecting" with others in HEOL. To the best of the researcher's knowledge, while there have been attempts to analyse certain aspects of CoPs and CoIs with SNA, a framework such as the IMF does not exist. At the time of writing of this research, the IMF has been tested in four case studies (Jan & Vlachopoulos, 2018a [Chapters 5]; Jan & Vlachopoulos, 2018b [Chapter 6]; Jan 2018 [Chapter 7]; Vlachopoulos, Matos, & Koutsogiannis, under review) which have effectively used it to identify online CoPs and CoIs formed under the influence of different learning designs.

By acting as a preliminary filter, the IMF reduces or perhaps even eradicates the need for extensive qualitative analysis previously required in research on CoPs and CoIs. By virtue of its' applicability to real-time, ongoing, online data, the IMF affords active evaluation of CoPs and/or

CoIs thereby cultivating the immediate practical value of the CoP and CoI frameworks, the lack of which is a shortcoming of qualitative methodologies. The IMF is a tool that can detect the presence or emergence of a CoP or CoI and inform learning design actively and retrospectively for future refinement. By operationalizing SNA constructs in structural components of CoPs and CoIs, the IMF also provides pedagogical grounding to SNA. In its current form, the IMF promises to be a valuable tool for academics and researchers of learning communities who are acquainted with SNA and who wish to evaluate CoPs and/or CoIs, actively or retrospectively, based on the structure of the underlying networks. For wider applicability of the framework, it would need to be automated and embedded within LMSs for use by lecturers, tutors, learning designers, and even students who wish to design and/or engage in CoPs or CoIs. The IMF is grounded in literature, draws on case-studies, and has successfully undergone blind peer-review, all of which affirm the validity of the framework (Inglis, 2008).

1.5 Methodology

This thesis comprises of five stand-alone research papers, each based on a different set of data. The thesis follows a sequential mixed method approach inclusive of exploratory systematic literature reviews and multiple case studies (Yin, 2009). The choice of methodology and guiding research questions in each research paper was driven by the overarching research question presented in section 1.3. Table 1 below lists the research papers, the purpose of each and justification for using the methodology.

Table 1. Methodology Used in Research Articles

Paper	Objective	Methodology	Justification for the methodology
1	Review of literature on the use of SNA to investigate CoPs and CoIs in HEOL	Exploratory systematic literature review	Consolidation and evaluation of SNA constructs used previously for structurally exploring CoPs and CoIs in HEOL
2	Review of literature on the use of SNA to investigate CoPs in any context	Exploratory systematic literature review	Consolidation and evaluation of SNA constructs used previously for structurally exploring online CoPs in any context. The review was prompted by the lack of literature found in (1) on CoPs HEOL

3	Development of a methodological framework for investigating CoPs and CoIs using SNA as the key methodology	Methodological framework development based on existing literature Preliminary quantitative case-study	In combination with additional literature, findings from (1) and (2) informed the development of the framework. The paper includes a preliminary case-study to demonstrate application and interpretation of the framework
4	Validation of the methodological framework	Mixed-method case-study	Demonstration and testing the effectiveness of the framework
5	Validation of the methodological framework	Quantitative case-study	Demonstration and testing the effectiveness of the framework

The research papers in this thesis follow a natural sequence whereby findings of one inform the guiding research questions of the next. The first two papers are exploratory systematic literature reviews. The first review (Chapter 3, Paper 1) was conducted to obtain guidelines for development of a SNA based methodological framework for investigating CoPs and CoIs in HEOL. However, the finding of a lack of studies that integrate SNA with the CoP framework in HEOL prompted the need for the second systematic review (Chapter 4, Paper 2) which explores the use of SNA to investigate online CoPs in any context. Findings from both systematic reviews were consolidated with additional literature to develop the IMF which is presented in the third paper (Chapter 5, Paper 3). This paper also includes a preliminary case-study on a blogging network to demonstrate the application and interpretation of the IMF. The fourth (Chapter 6, Paper 4) and the fifth (Chapter 7, Paper 5) research papers comprise of detailed case-studies conducted to validate the IMF. The case-studies demonstrate application and interpretation of the framework on discussion forums of different designs and durations. The case-studies validate how the IMF is used to detect the emergence of a CoP or CoI or lack thereof under the influence of different learning designs and how the IMF can be used to conduct ongoing analytics from online data to inform impromptu learning design and future refinements to learning design. All of the stand-alone research papers in this thesis are interrelated and align with the key objective of the research. Table 2 presents the data used in each paper along with a justification for using the data.

Table 2. Data Used in Research Papers and Justification for Using the Data

Paper	Data	Justification for Using the Data
1	Database searches on ERIC, Scopus and Ebscohost for peer-reviewed journal articles and conference papers in English.	ERIC- most used database for educational literature. SCOPUS - one of the largest databases of peer-reviewed research. EBSCOhost – includes numerous databases spanning multiple disciplines.
2	Database searches on ERIC, Scopus and Ebscohost for peer-reviewed journal articles in English.	ERIC- most used database for educational literature. SCOPUS - one of the largest databases of peer-reviewed research. EBSCOhost – includes numerous databases spanning multiple disciplines.
3	Findings from Paper 1 and Paper 2 combined with additional literature. Interaction data from the LMS on a blogging activity over 5 weeks.	Development of theoretically grounded framework based on high quality literature selected systemically in (1) and (2). Preliminary case-study to test and validate the framework.
4	Interactional data from the LMS on 3 differently designed discussion activities of equal duration within the same course.	Detailed case-study to test and validate the framework.
5	Interactional data from the LMS on discussion activities in two offerings of the same course differing in design (facilitation) and duration only.	Detailed case-study to test and validate the framework.

1.6 Thesis Format and Structure

This thesis by publication comprises of 8 chapters inclusive of 5 stand-alone published research papers all of which have undergone a blind peer-review in international scholarly journals. Valuable formative feedback provided by reviewers of the papers has contributed to the quality of the publications. The thesis has been formatted in accordance with Macquarie University guidelines. The in-text citations in each published paper follows the format stipulated by the respective journals. APA reference format is used for non-published work and combined reference list. Tables, figures and sections in the papers have been renumbered for coherence and consistency.

Chapter One introduces the research, establishes the rationale for undertaking the research, states the key objective and contribution of the research to the field of HEOL.

Chapter Two expands on the literature in chapter one. The chapter discusses the historical evolution and significance of learning communities leading up to the establishment of the community-based theoretical frameworks, that is, CoP and CoI. The chapter then unfolds the CoP and CoI frameworks in the context of HEOL and establishes the pedagogical significance of the frameworks. With an overview of previous research using the CoP and CoI frameworks in HEOL and the research methodologies used, implications for practice are discussed. Following this, the importance to educators of examining and understanding the structure of CoPs and CoIs is established along with the use of SNA as an appropriate methodology to achieve this.

Chapter Three presents the first of two systematic literature reviews conducted to explore how SNA has been used in HEOL to investigate CoIs and CoPs.

> Jan, S. K., Vlachopoulos, P., & Parsell, M. (2019). Social network analysis and learning communities in higher education online learning: A systematic literature review. *Online Learning, 23*(1), 249-264.

Chapter Four presents the second systematic literature review conducted to explore how SNA has been used to investigate online CoPs in any context. Impetus for conducting this review was provided be findings of the first systematic review presented in Chapter Three which only identified one study using SNA to investigate CoPs in HEOL. Again, the objective for conducting this review was to borrow from literature in contexts other than HEOL to inform the development of the IMF.

> Jan, S. K. (2019). Investigating virtual communities of practice with social network analysis: guidelines from a systematic review of research. *International Journal of Web-based Communities, 15*(1), 25-43.

Chapter Five presents the IMF detailing its' development, application and interpretation. The chapter includes a preliminary case-study on an online blogging network.

Jan, S. K., & Vlachopoulos, P. (2018). Social network analysis: A framework for identifying communities in higher education online learning. *Technology, Knowledge and Learning*. https://doi.org/10.1007/s10758-018-9375-y

Chapter Six presents the second case-study in which the IMF is used to explore community formation and evolution in three differently designed discussion forums in an online course of study.

Jan, S. K., & Vlachopoulos, P. (2018). Influence of learning design on the formation of online communities of learning. *International Review of Research in Open and Distance Learning*, (19)4. https://doi.org/10.19173/irrodl.v19i4.3620

Chapter Seven presents the third case-study in which the IMF is used to explore community formation and evolution in two differently designed offerings of the same online course.

Jan, S. (2018). Identifying online communities of inquiry in higher education using social network analysis. *Research in Learning Technology, 26*. https://doi.org/10.25304/rlt.v26.2064

Chapter Eight concludes the thesis with an overview of the findings, limitations of the research, contribution to knowledge, implications of the research, and suggestions for further research.

2. Chapter II: Learning Communities in Higher Education

Foreword

In the previous chapter I introduced my research with a brief background, the key objective and the research questions that have guided my work. To reiterate, the focus of my research lies at the intersection of learning communities, specifically, CoPs and CoIs and SNA. This chapter delves deeper into community-based learning. The research objective depicted by the intersection in my conceptual framework (Chapter 1, Figure 1, p. 17), represents the structural components of CoPs and CoIs and those SNA constructs that can be used as parallels to understand the structural dynamics within the communities. Before I proceeded to identify the relevant SNA constructs, it was necessary to unpack why a structural understanding of learning communities is essential from a pedagogical perspective. Finding the appropriate SNA constructs is one thing, however, the key was figuring out how findings from the SNA could be interpreted in terms of their educational value and implications for teaching and learning in the HEOL context. Therefore, this chapter unravels the rationale for undertaking this research by considering questions such as: Why are learning communities important? Why is community-based learning pedagogically meaningful? How are connections or interactions between individuals indicative of learning? In other words, what is the role of interactions in community-based learning? What are the key characteristics of CoPs and CoIs? What are their differences? Why are they significant in HEOL? How have they been researched? What is missing? so on and so forth.

This chapter forms the foundation of my PhD as the literature and ideas contained in it have guided and informed my research throughout. It is important to note that this chapter was written after publication of the five research papers, all of which contain condensed versions of some section or the other from it, an unavoidable duplication needed to explain the

background for each. However, as will be evident, the literature and discussion in this chapter are far more detailed and formalized in comparison to the chapters following it.

2.1 Overview

The first section of this chapter traces the historical significance of learning communities dating back centuries to the currently pervasive online learning communities. It touches upon the prominent influences and developments that have contributed to shaping the current landscape of learning communities in the context of higher education. Following this, the next section reviews the major pedagogies underlying community-based learning with special attention to the role of interactions between individuals in the learning process. This section leads up to the development of the Communities of Practice (CoP) and Community of Inquiry (CoI) frameworks which have been commonly applied to research in higher education online learning (HEOL). The remainder of the chapter provides an overview of the CoP and CoI frameworks focusing on the structural (interactional) aspects of each. For each type of community, an overview of literature on its' application in the HEOL context is provided, existing research methodologies are discussed, and the need for but lack of consideration to the structural components of the frameworks is highlighted. Finally, pulling together key gaps identified throughout the chapter, the rationale for undertaking this research is presented.

2.2 Historical Significance of Learning Communities

Origins of communal learning can be traced back to ancient philosophers and religions from non-western societies. For instance, the idea of learning from peers, experts, and scaffolding can be found in Confucianism (551-479 BC) which conceptualizes learning as the process of "Imitation of the conduct of the sage…" (Merriam, Caffarella, & Baumgartner, 2007, p. 226). Confucian Analects state that "there must be a role model even when a few people take off on the road together" and "that teachers must wait until adult learners understand by themselves; then, at this time, teachers must again help learners understand through individual learning" (Sung, 1991z, p. 139 as cited in Merriam et al., 2007, p. 227). Islam, religion of the Muslims, lays an emphasis on commitment to learning of the community, sharing of knowledge, and the sacredness of the teacher-student relationship (Merriam et al., 2007). In the ancient western world, a first attempt at developing an inquiry-based community of intellectuals can be found

Plato's school in which "… the young men who came to Plato's school were prepared to spend not only their days but their nights in study, learning, and training. The Academy was a school, a home, a church, and a moral society all wrapped in one" (Power, 1964, p. 162).

The history of formally recognized communities in the context of higher education dates back to the western world, specifically, the European residential college model of the 12th century founded at the University of Paris and Oxford University. Considered to be the "oldest organization in Western higher education" (Residential Colleges, 2018, para. 1), the residential college model formed the basis on which the academic communities of Oxford University and University of Cambridge (Oxbridge) were later developed. The Oxbridge academic communities comprised of "students and faculty sharing living quarters, meals, and tutorial study" (Residential Colleges, 2018, para. 1) where community members (lectures, students, staff, etc.) co-existed and shared living quarters, engaged socially as well as academically. The Oxbridge model penetrated and influenced educational institutions across the globe. In the 19th century, the Germanic model of higher education gained prominence over the Oxbridge academic community model. The Germanic model lay a greater emphasis on academics, for instance, academic freedom, scholarship, achievement, and training (Inkelas & Soldner, 2012). The model became, "the most admired institution of higher education in the Western world" in the 19th century (O'Boyle, 2009, p. 1). Features of the Oxbridge and Germanic models of higher education are evident in the residential and academic structure of modern-day colleges and universities across the globe.

The pedagogical and structural foundations of contemporary learning communities are attributed to the ideas of John Dewey (1859-1952) and John Meiklejohn (1836-1902). Dewey, who is regarded as one of the most prominent contemporary learning community theorists (Gabelmick, Macgregor, Matthews, & Smith, 1990) was critical of the Germanic model for not engaging students completely. The structural roots of contemporary learning communities can be traced to the works of Meiklejohn" in the 1920s (Gabelmick et al., 1990, p. 11). Meiklejohn believed in the "fundamental importance of structure, curricular coherence, and community" (Gabelmick et al., 1990, p. 12). His concept of learning communities differed from Dewey's in that he advocated the importance of "integration of ideas across disciplines and restructuring the curriculum across courses and semesters" (Love, 2012, p. 9). Both Dewey and Meiklejohn believed in learning as a social process in which students, teachers and the community interact

with one another and learn democratically (Smith, Macgregor, Matthews, & Gabelmick, 2004). Both founded experimental institutions to practically apply their theories. Dewey setup an elementary school whereas Meiklejohn introduced the first Experimental College program (1927-1932) at the University of Wisconsin in the United States. Even though the Experimental College program was short-lived, over the next few decades from its' inception, numerous universities adopted and adapted the model based on lessons learnt from the program (Meikeljohn, 1932).

Following a relatively quiet period, in the 1960s and 70s the idea of learning communities re-emerged with the significant rise in higher education institutions in the United States and establishment of community colleges (Smith, 2001). This brought with it the interest of educational researchers who sought to explore the efficacy of learning communities. In the 1980s, the recognition that learning in a community leads to higher levels of learning and development began to surface (Zhao & Kuh, 2004). Literature refers to this era as the beginning of the *learning community movement* (Smith, 2001) which gained greater momentum in the 1990s when several studies were published showing a positive link between participating in learning communities and better outcomes for college students (Matthews 1994; Pike, 1999; Tinto, 1998). For instance, researching factors impacting student retention, Tinto (1987) "theorized that 'students' social and intellectual integration into the academic and social communities of college are essential factors in determining whether students will stay in college and complete their degree" (Love, 2012, p. 6). Taylor, Moore, Macgregor and Lindblad's (2003) review of research on learning communities prior to 2003 concluded that "those studies that looked at retention, academic success, and satisfaction reported overwhelmingly positive results. The findings held without regard to the size of the study or the type of learning community undertaken, suggesting that even modest learning community initiatives are likely to reap positive outcomes" (Taylor et al., 2003, p. 19). Post 2000 research studies also show a positive relationship between learning within communities and students' achievement of goals (Buch & Spaulding, 2008), engagement levels and well-being (Finley, 2009), performance (Hanson & Heller, 2009), persistence and success (Engstrom, 2008), and retention (Wolff & Tinney, 2006).

The learning community movement did not remain restricted to physical or face-to-face communities. Technological developments starting with the invention of emails in 1971 and listservers in 1975 allowed groups of individuals to communicate virtually. This formed the beginnings of what are now referred to as online or virtual communities (Preece, Maloney-

Krichmar, & Abras, 2003). In 1985, the first widely recognized online community, The Whole Earth 'Lectronic Link (WELL) was established (Rheingold, 1993). In the late 1900s, groups interacting online were commonly viewed as communities where one would go to engage with others and establish and maintain social bonds (Jones 1995; Ludlow, 1996; Rheingold, 1993). Online communication and collaboration technologies penetrated the field of higher education as well. In the early 1990s, several higher education institutions began to offer online courses replacing traditional distance education. As online courses gained popularity, in the late 1990s, terms such as e-learning and online learning became common place. Adding to the momentum of the learning community movement, findings from research studies on online learning corroborated the effectiveness of community-based learning which became the holy grail of online learning. As stated by Palloff and Pratt (1999), "without the support and participation of a learning community, there is no online course" (p. 29). With significant advancements in technology and consequently greater penetration into the field of higher education, the last two decades have witnessed a plethora of research on online communities re-affirming that learning in communities is the way to learn. For instance, communities are considered as essential for knowledge generation which is an integral component of the learning process (Garrison & Anderson, 2003). Kop and Hill (2008) state that "the starting point for learning occurs when knowledge is actuated through the process of a learner connecting to and feeding information into a learning community" (p. 2). Mayes and de Frietas (2004) describe "The 'modal pedagogy model' would describe how to engage the learners in meaningful tasks, give rapid feedback, encourage reflection through dialogue with tutors and peers, align assessment, and would encourage through discussion the creation of a community of learners" (p. 23). Learning in various forms of community has been described as "necessary for creating and confirming meaning and…essential for achieving effective critical thinking" (Swan, Garrison, & Richardson, 2009, p. 4).

In summary, from the Oxbridge residential college model, to the Germanic model of higher education, to Meiklejohn's Experiential College and future variations of it, to the currently pervasive online learning communities, there is abundant literature on the significance of community-based learning in traditional and online learning environments. The term 'learning community' is used very broadly now a days (Love, 2012) as learning communities of today take various forms and shapes (online and face-to-face), for instance, curricular learning communities, residential learning communities, interest-based learning communities, communities of practice

(CoPs), communities of inquiry (CoIs), personal learning networks, professional learning communities, knowledge-based communities and the list goes on. It is important to note that the historical dichotomy between curricular-based communities and communities that refer to groups of individuals is not always obvious in literature. The boundaries between the two may overlap especially in the context of online learning therefore a clear distinction is deemed necessary. Thus, the term *structure* in this chapter here onwards refers to the structure of the community that emerges from interactions between individuals, not the curricular structure of learning communities.

2.3 Major Pedagogical Underpinnings of Learning Communities

The significance of community-based learning lies in the pedagogical processes underlying learning communities. Most contemporary learning community models and frameworks borrow from the sociocultural or socio-constructivist learning perspectives (Mayes & de Frietas, 2004). An examination of the basic tenets of the pedagogies underpinning learning communities brings the importance, in the learning process, of the role of interactions and consequent structural configuration of the community to the forefront.

Dewey (1859-1952), Piaget (1896-1980), and Vygotsky's (1896-1934) philosophies form the foundations of the constructivist learning tradition (Kensalaar, 2002), the overall pedagogy underpinning community-based learning. An advocate of student-centred, active, and collaborative learning (Fink & Inkelas, 2015), for Dewey the ideal learning environment would comprise of academic and co-curricular activities that engage students and teachers in shared inquiry (Smith et al., 2004) grounded in real and practical experiences. One of the central concepts in Dewey's philosophies is interaction, not only with others but between the internal and external, that is, the individual and his or her environment (Knowles, 1988). Conceptualizing experience (education) as an outcome of a transaction between the self and the environment, Dewey states, "An experience is always what it is because of a transaction taking place between an individual and what, at the time, constitutes his environment (Dewey, 1938, p. 41). Dewey theorizes education as a democratic and social process in which students and teachers engage in shared inquiry on an equal platform. He states, "The principle that development of experience comes about through interaction means that education is essentially a social process. The teacher loses the position of external boss or dictator but takes on that of leader of group

activities" (Dewey, 1938, p. 61-66). It is these interactions between groups of individuals (teachers and students) that brings them together to form learning communities and it is their common interests, discourse, and shared purpose that keeps them together thereby providing the environment for shared practical inquiry.

Historically, constructivism has comprised of two major strands, cognitive constructivism and social or socio-constructivism (Kensalaar, 2002). While the fundamental principles of constructivism inform both strands, each attributes knowledge construction to different internal and external processes (Doolittle & Hicks, 2003). Piaget (1952) is credited with the development of cognitive constructivism, the basic premise of which is that intellectual development occurs via the internal, cognitive processes of assimilation and accommodation of new information into existing mental schemas or representations. On the other hand, socio-constructivism is rooted in Vygotsky's (1978) sociocultural theory which attributes knowledge construction to the role of language, thought, culture, and society (Kensalaar, 2002). As per the sociocultural perspective, "The mental processes and schemata of cognitive activity that constructivism emphasizes are formed in and through participation in specific social practices, culturally and historically situated" (Packer & Goicoechea, 2010, p. 234). In other words, intellectual development takes place via social interactions embedded in social and cultural contexts in which learning is negotiated through a culture's symbols and language arising from interactions with others in the culture (Merriam et al., 2007). Vygotsky (1978), whose earlier works were influenced by Dewey (Glassman, 2001), emphasized the significance of teacher-student communication in the learning process especially the dialogue and co-construction of knowledge within what is called the zone of proximal development (ZPD). The ZPD is described as the difference or distance between what a learner can do and cannot do without help (Verenikina, 2008). This idea of teachers or experts providing the help, also known as, scaffolding (Wood, Brunner, & Ross, 1976) in the ZPD has seen wide applications in the field of education in all age groups and modes (face-to-face and online) of learning. Here again, processes such as student-teacher communication, co-construction of knowledge, scaffolding in the ZPD, etc. are embedded in the interactions that takes place between individuals. Without the interaction, there would no transaction which signifies learning.

Sociocultural theories have been referred to as the 'structural perspectives on understanding' as opposed to cognitive constructivism which has been called the 'functional' perspective of

understanding (Packer & Goicoechea, 2010). The structural perspective refers to the role of interactions in the learning process. As per sociocultural theorists, two types of knowledge cannot be measured concretely, that is, knowledge which is constructed in the activities or practices of groups, and knowledge that becomes embedded in artefacts or tools. Such knowledge is what is referred to as knowledge that is situated in a context and is commonly termed situated learning or distributed cognition (Kensalaar, 2002). Prominent contemporary contributions to the situated learning or distributed cognition perspective include the works of Lave (1988), Brown, Collins and Duguid (1989), and Lave and Wenger (1991), among others. Speaking on the nature of cognition, Lave (1988) describes cognition as a, "a complex social phenomenon … distributed—stretched over, not divided among—mind, body, activity and culturally organized settings (which include other actors)" (p. 1). As per Brown et al. (1989) "understanding is developed through continued, situated use" involving "complex social negotiations" (p. 33), so that "learning and cognition … are fundamentally situated" (p. 32) in activity, context, and culture" (cited in Packer & Goicoechea, 2010, p. 229). Again, individual and contextual interactions underpin the situated learning and distributed cognition perspectives. In this case, interactions not only signify the learning process but embody the abstract knowledge situated within the exchange or transaction.

The socio-constructivist perspective which is associated with multiple contemporary theories (e.g. Bruner and Badura's social cognitive theory (Schunk, 2012)) along with the Vygotsky's (1978) sociocultural theory (Kim, 2001) also lays an emphasis on culture and context in the learning process. It postulates that knowledge is "constructed when individuals engage socially in talk and activity about shared problems or tasks. Making meaning is thus a dialogic process involving persons-in-conversation, and learning is seen as the process by which individuals are introduced to a culture by more skilled members" (Driver at al., 1994, p. 7). According to socio-constructivists, the social and individual are inseparable, and cognitive development is an outcome of interactions within a group (Crompton, 2013). A community, literally defined as, "an interacting population of various kinds of individuals (species)…" (Merriam-Webster, 2018), provides the ideal structure for supporting sociocultural or socio-constructivist pedagogies which, naturally or if cultivated intentionally, transform the community into a learning community where knowledge is constructed and learning takes place. Communities are formed when individuals engage in dialogue, that is, mutual or reciprocal exchange. Learning communities are formed when the mutual exchange is meaningful and leads to knowledge

construction. In the educational context, this meaningful exchange occurs between teachers and students or the students amongst themselves. Teachers and students bound within a learning community interact with one another in the learning process. It is these interactions that support shared inquiry, scaffolding, negotiation of meaning, and co-construction of concrete and abstract knowledge. It is these interactions that sustain shared interests and hold the community together. Hence, a complete understanding of the nature of learning communities warrants an appreciation of the unique interactional or structural dynamics within each.

Connecting the behavioural and cognitive with the social (Mayes & de Frietas, 2004), the sociocultural or socio-constructivist theories emerged as a reaction to the preceding behaviourist and cognitive learning perspectives (Kensalaar, 2002). A manifestation of the sociocultural or socio-constructivist perspectives, community-based "Learning entails both personal and social transformation" (Packer & Goicoechea, p. 228) which is supported by the structure of learning communities that affords "learning as behaviour, learning as the construction of knowledge and meaning, and learning as social practice" (Mayes & de Frietas, 2004, p. 11). The past couple of decades have witnessed a plethora of models and frameworks for exploring, designing and assessing learning communities specially in the context of HEOL. As mentioned earlier, majority of these models and frameworks are grounded in sociocultural or socio-constructivist perspectives. Of these models and frameworks, the CoP (Wenger, 1998) and CoI are two of the most popular, established, and empirically tested community-based learning frameworks that have seen significant application in online learning. Interactions between individuals lie at the crux of both frameworks however, the frameworks are contextually and conceptually distinct. Whether the nature of interactions within the two types of communities reflects this distinction is the topic of Chapters 3, 4 and 5 which include two sequential systematic literature reviews and a methodological framework developed from findings of the systematic reviews.

2.4 Community-based Learning Frameworks

The CoP and CoI frameworks are community-based learning frameworks rooted in the sociocultural and socio-constructivist theories of learning. As such, interactions with others and the environment play a prominent role in the learning process in each. However, owing to the context in which each framework was developed and different theoretical orientations, interactions within a CoP and CoI have been conceptualized differently. The CoP framework finds its origin in the context of professional learning whereas the CoI framework was specifically

developed for online pedagogy and research. In its originality, a CoP was theorised as a natural occurrence whereas, a CoI was conceptualized as a learning community that can be intentionally designed and cultivated. The CoP framework is a social theory of learning which describes learning as a process of *participation* whereas, the CoI framework rests on the *transactional* view of learning. The CoP framework has evolved and developed considerably since its inception while despite researchers arguing for and proposing amendments and additions to the CoI framework (Garrison, 2017), the CoI framework remains in its original form. Both frameworks have been applied substantially in the educational context and continue to hold an important place in the field of HEOL.

2.4.1 The Communities of Practice Framework

Since the introduction of the theory of situated learning (Lave & Wenger, 1991) and formalisation of the CoP framework (Wenger, 1998), the framework has evolved considerably. However, the essence and defining features of a CoP have remained the same. Progressive seminal publications on the CoP framework (Lave & Wenger, 1991; Wenger, 1998, Wenger, McDermott, & Snyder, 2002) have taken on different key concerns (Cox, 2005) based on the needs of time and context of development. A detailed examination and discussion of all aspects of the framework to date is beyond the scope of this chapter which focuses on the participatory or structural components of a CoP and aims to provide the reader with an overview of the framework's evolution over time. Therefore, the following section is restricted to a discussion of the key concepts in the formative publications on the CoP framework.

2.4.1.1 Overview

Conceptual foundations of the CoP framework can be traced back to the works of Edward Constant (1987) and Julian Orr (1990) who used examples of photocopiers to describe learning as a social process embedded in the environment. Lave and Wenger (1991) are typically cited as originators of the term *Communities of Practice* although Brown and Duguid (1991) simultaneously used the term. The CoP framework, as introduced by Lave and Wenger (1991), and later formalized by Wenger (1998) is rooted in anthropology (Lave, 1998) and other social learning theories (e.g. Bourdieu, 1977; Foucalt, 1980; Giddens, 1984; Vygotsky, 1978). In the book *Situated Learning: Legitimate Peripheral Participation*, based on studies of apprenticeships (midwives, tailors, butchers, etc.), Lave and Wenger (1991) proposed the theory of situated

learning which postulates learning as an inherently social process situated within cultural and historical contexts. Rooted in Vygotsky's (1978) sociocultural perspectives of learning, the situated learning theory explains learning as collective knowledge involving sharing of ideas and discourse. Linked to Vygotsky's (1978) zone of proximal development (ZPD) and the concept of scaffolding in the ZPD (Wood, Brunner, & Ross, 1976), Lave and Wenger (1991) introduced the seminal concept of legitimate peripheral participation (LPP), a process by which newcomers enter a group and eventually evolve into experts by learning and adopting practices of the group. LPP is a cyclical activity which signifies learning as it leads to the development of individual and collective identities through the processes of participation and reification (explained below).

In the book *Communities of Practice*, Wenger (1998) further developed and formalized the concept of a CoP theorising from an empirical study of claims processing officers at an insurance company. Wenger (1998) details three aspects of practice that define a CoP: mutual engagement, joint enterprise and, a shared repertoire. Mutual engagement is referred to as the interactions between participants that lead to the construction of common meaning through negotiation. Joint enterprise is defined as the process of mutual engagement and actions towards achieving a shared goal. Shared repertoire is the common resources and terminology used within the community. Wenger (1998) conceptualizes participation in a CoP as involvement in its activities, interactions, negotiations, and conceptual and material constructions which leads to what is called reification. Reification is "the process of giving form to experience by producing objects that congeal this experience into thingness" (Wenger, 1998, p. 58). Simply put, a reification provides concreteness to a concept. A common example of a reification would be grades (eg. A, B, C, …) as a measure of intelligence.

Wenger (1998) emphasises the inter-dependency between participation and reification. Reification requires participation and participation leads to reification. The dual concepts are complementary, inseparable and necessary for continuation of meaning (Farnsworth, Kleanthous, & Wenger-Trayner, 2016). Wenger (1998) attributes identity formation of CoP members to the rhythms of participation and non-participation. Furthermore, participation is categorized in terms of individual trajectories of learning (identity development) within a CoP as: full participation (insider); legitimate peripherality (inbound trajectory to becoming a full participant or in a circular trajectory around the periphery); marginality (outbound trajectory and is either moving from being a full participant to becoming an outsider or is restricted to the

periphery) and; full non-participation (outsider). In addition, Wenger (1998) conceptualizes identity as a mode of belonging to a CoP via engagement, imagination and alignment. Individuals engage in practice, using imagination to produce personal trajectories within the practice and align themselves to the customs of the practice.

Wenger (1998) also discusses overlapping CoPs meaning, individuals can belong to more than one CoP at a time. These individuals are located on the boundaries of the CoPs and act as brokers of knowledge between CoPs. Wenger (1998) theorizes that it is at these boundaries that innovation takes place and new knowledge is created as practices of the CoPs overlap and intermingle and members align themselves to new practices. Speaking of sustainability of a CoP, Wenger (1998) emphasises the criticality of the right balance between four dualities within a CoP: participation versus reification; designed versus emergent; local versus global, and identification versus negotiability. In light of this criticality, Wenger (1998) proposes a design framework for nurturing CoPs and then demonstrates its' application in the organizational and educational context. Throughout, the text, Wenger (1998) stresses on the inherently organic nature of CoPs "since practice is not the result of design but rather a response to it" (p. 233).

In the book *Cultivating Communities of Practice,* Wenger, McDermott and Snyder (2002) shift the focus from naturally occurring communities to communities developed, designed and cultivated by organizations intentionally to improve competitiveness. The three aspects of a CoP defined in Wenger (1998) are revised to: domain, community and practice: the domain is the common ground and defines the identity of the group, the community is the web of social relationships that facilitate learning by sharing, interacting, collaborating and discussing and, the practice is the shared repertoire of resources like, experiences, etc. Use of the term joint enterprise is discontinued to distinguish between a CoP and a team. Instead, domain is used "to define the area in which a community claims to have legitimacy to define competence" (Farnsworth, Kleanthous, Wenger-Trayner, 2016, p. 143). Even though the key components of a CoP are re-defined with some aspects re-classified, the defining characteristics of a CoP (e.g. shared interest, mutual exchange, practice, participation, reification, etc.) remain central to the framework. The concept of the web or network of social relationships which was implicit in Wenger (1998) is made explicit and emphasized. In view of the balance in the four dualities discussed in Wenger (1998), Wenger, McDermott and Snyder (2002) present seven design principals for cultivating CoPs. The principals focus on community evolution, significance and role of different levels of

participation, value creation, necessity of open dialogue internally and externally, and criticality of rhythms of participation. The role of a community coordinator for stewarding the CoP is introduced as are the three stages of CoP development, that is, formation, integration, and transformation. In alignment with the infusion of technologies across most functional areas of organizations, technology mediated online CoPs are also brought into the discussion by Wenger, McDermott, and Snyder (2002).

Addressing the needs of time arising from technological advancements and proliferation, in the book *Digital Habitats* (Wenger, White, & Smith 2009), the role of technologies in CoPs is brought to focus. A digital habitat is described as a dynamic structure in which community, network and technologies are intertwined in a complex iterative relationship in which one drives the other. The characteristics of CoPs are discussed with technology as the central the agent shaping CoPs (digital habitats). Again, maintaining the crux of the framework conceptualized in Wenger (1998) and Wenger, McDermott, and Snyder (2002), emphasis is laid on the right balance between the dualities which are re-classified and are now referred to as three polarities which include: rhythms (togetherness and separation), interactions (participation and reification) and, identities (individual and group). The key to a sustainable thriving digital habitat is placed in finding the right balance between the three inherent polarities which drive communities to adopt technologies. Additionally, the role of the community coordinator is re-conceptualized in terms of a technology steward who among other things, "shapes how the community 'gets together' and how productive it is" (Wenger, White, & Smith, p. 29). Having described the dynamics of a digital habitat, Wenger, White, and Smith (2009) move on to providing practical guidelines for assessing communities and present what they call, a practitioner-oriented summary or action notebook for technology stewardship. In more recent works, *Learning in Landscapes of Practice*, Wenger-Trayner and Wegner-Trayner (2014) present the notion of landscapes of practice which are systems of CoPs and identities that span a number of practices in which competence or expertise cannot be claimed. "Theoretically, it [the book] represents a new step in the evolution of the theory" (Wenger-Trayner, 2014, para. 1), the full implications of which are under exploration.

2.4.1.2 Online Communities of Practice

The CoP framework originated in the context of face-to-face CoPs however, technological advancements and infiltration in most personal and professional spheres prompted extension of

the framework to the online space. Online CoPs comprise of individuals that come together due to "shared practices, information, and knowledge that exists for them through mainly electronic means such as online forums, bulletin boards, and email" (Fang & Chiu, 2010, p. 236). Online CoPs are considered to be similar to face-to-face CoPs (Rheingold 1993; Thorpe, McCormick, Kubiak, & Carmichael, 2007; Wilson 2001) however, "technologies extend and reframes how communities organize and express boundaries and relationships, which changes the dynamics of participation, peripherality, and legitimacy" (Wenger, et al, 2009, p. 11). For instance, "The simple action of logging into the platform is a mask of participation and membership" (Wenger et al., 2009, p. 50). Online CoPs can form organically or can be formally designed and orchestrated. Common examples of spontaneously formed online CoPs include face book groups or twitter communities based on a common interest. Formal, designed and orchestrated online CoPs can be found within online platforms of organizations or educational institutions (e.g. learning management systems) and even within social media.

Regardless of whether a CoP is face-to-face or online, the defining characteristics of a CoP remain the same however, research on online CoPs needs to take into account some differences between physical and online CoPs (Gairin-Sallan, Rodriquez-Gomez, & Armengol-Asparo, 2010; Johnson, 2001; Lai, Pratt, Anderson, & Stigter, 2006). Online CoPs:

- Are not restricted by space or time.
- Are based on shared interest or an activity rather than enforced by shared location.
- Have fluid boundaries unless restrictions have been out in place intentionally.
- Allow greater individual autonomy and more time for reflection as exchange is restricted to written text or other media and therefore not as spontaneous.
- Have greater diversity in members due to lack of geographical boundaries and therefore a bigger knowledge base.
- Typically take a longer time to develop and require facilitation or leadership and technological support such as that provided by a technology steward.
- Can be researched using real time, complete, valid and reliable data from the online platform use for communication.

Note that the systematic literature reviews in Chapter 3 (Paper 1) and Chapter 4 (Paper 2) were restricted to online CoPs in view of these differences between face-to-face and online communities.

2.4.1.2.1 Communities of Practice in HEOL

Before conducting research on CoPs, albeit face-to-face or online, the context in which the CoP is situated needs to be clarified and specified as findings should be interpreted accordingly. CoPs in HEOL are a subset of the online CoPs discussed above with some variations. In HEOL, CoPs are typically formed within learning management systems (LMSs) or social media which is often times used for educational purposes. It is important to note that interactions over social media are not constrained (unless closed groups are used as in the case of a face book group) within the LMS therefore, the CoPs formed over social media are different. In the context of CoPs within LMSs in HEOL:

- The practice of the CoP is defined by the shared interest in teaching and learning within the particular course of study. Therefore, students, lectures and tutors engage in the practice of teaching and learning.
- The online interactions between students, lecturers and tutors constitute the network or web of social relationships that underlie a CoP.
- A CoP can develop and evolve organically under the influence of a learning design but does not form naturally since students who enrol in a course of study are bound to participate in its' activities. Therefore, the CoP is restricted to the students, lecturers and tutors within the course.
- Unless outside experts are invited to participate in the course, the boundaries of the CoP are restricted to the student cohort and are therefore not fluid and permeable.
- The duration over which a CoP can evolve is limited to the duration of the course of study.
- Finally, the shared repertoire of the CoP including resources, material and conceptual reifications are captured within the LMS, data for which is easily extractable retrospectively or in real time.

The data in the case-studies in Chapter 5 (Paper 3), Chapter 6 (Paper 4) and Chapter 7 (Paper 5) is analysed within the parameters listed above.

2.4.1.2.2 Applying and Researching the CoP Framework in HEOL

In the educational context, the CoP framework has been used to investigate, among other things, inclusive education, vocational education, and professional development of teachers, and online

learning communities (Farnsworth, Kleanthous, Wenger-Trayner, 2016). The framework has been used to explain learning metaphorically to inform how instruction should take place (Hoadley, 2012). As per the CoP framework learning requires participation, that is, interactions with others. Participation is necessary for reification. The reification gives meaning to the participation. The meaning is then negotiated by further participation or interaction which leads to further reification, and so on and so forth. This cyclical process (LPP) of meaning-making or knowledge construction describes the inherent learning process which leads to the development of identities. As such, researchers or practitioners who design and investigate learning or professional environments to cultivate or evaluate CoPs, do so assuming that learning within CoPs is the most effective way to learn. Educational researchers typically assume a positive association between indicators of a CoP and better outcomes for students.

The CoP framework is amongst the most widely cited influential social learning theories (Farnsworth, Kleanthous, & Wenger-Trayner, 2016) that has guided research on online and blended learning in higher education (Smith, Hayes, & Shea, 2017). A search for studies on online CoPs returns a large number of articles however, studies that actually integrate their analyses with components of the CoP framework are limited (see Chapter 3, Paper 1; Mcloughlin, Patel, Callaghan, & Reeves, 2018; Smith, Hayes, & Shea, 2017). In a recently published literature review, Smith, Hayes and Shea (2017) identified only 17 out of 82 studies on online and blended learning that grounded their findings and analyses in the CoP framework. Majority of these studies concerned theory verification, that is, examined data to establish presence of CoP features. A detailed review of these studies shows that all but one used mixed methods to explore aspects of mutual exchange, shared repertoire, and identity development with little emphasis on participation or interactions. Studies on online CoPs rely heavily on qualitative analysis. Of the 17 studies reviewed by Smith et al. (2017), only two allude to some structural (participatory) aspects (e.g. trajectories, brokerage, core) of an online CoP. For instance, in a study on art and design graduates' identity development during their training as teachers, Adams (2007) makes a reference to the inbound trajectories of the students as they negotiate their identities. Similarly, investigating an initial teacher education course, Clarke (2009) reports that students share their practice, reflections, ideas, and resources, and act as brokers, etc. forming an active community.

It comes as a surprise that research on CoPs in HEOL has not paid much attention to the essence of the CoP framework, that is, participation. It is the interactions that signify participation and

the LPP process. It is the interactions that support mutual exchange and represent the joint enterprise and practice. It is the interactions that determine individual trajectories which in turn signify learning. As discussed earlier, participation and reification are dual processes that run parallel to one another. Higher participation means higher reification therefore greater knowledge construction and learning. Higher participation places members in the core of the community therefore, presumably the core signifies a higher degree of reification as well. Thus, it is the interactions that support the reification. Wenger (1998) visually conceptualizes a CoP in terms of LPP as shown in Figure 2 below, however, in the book and future publications, the holistic structure and inclusive dynamics are not elaborated upon.

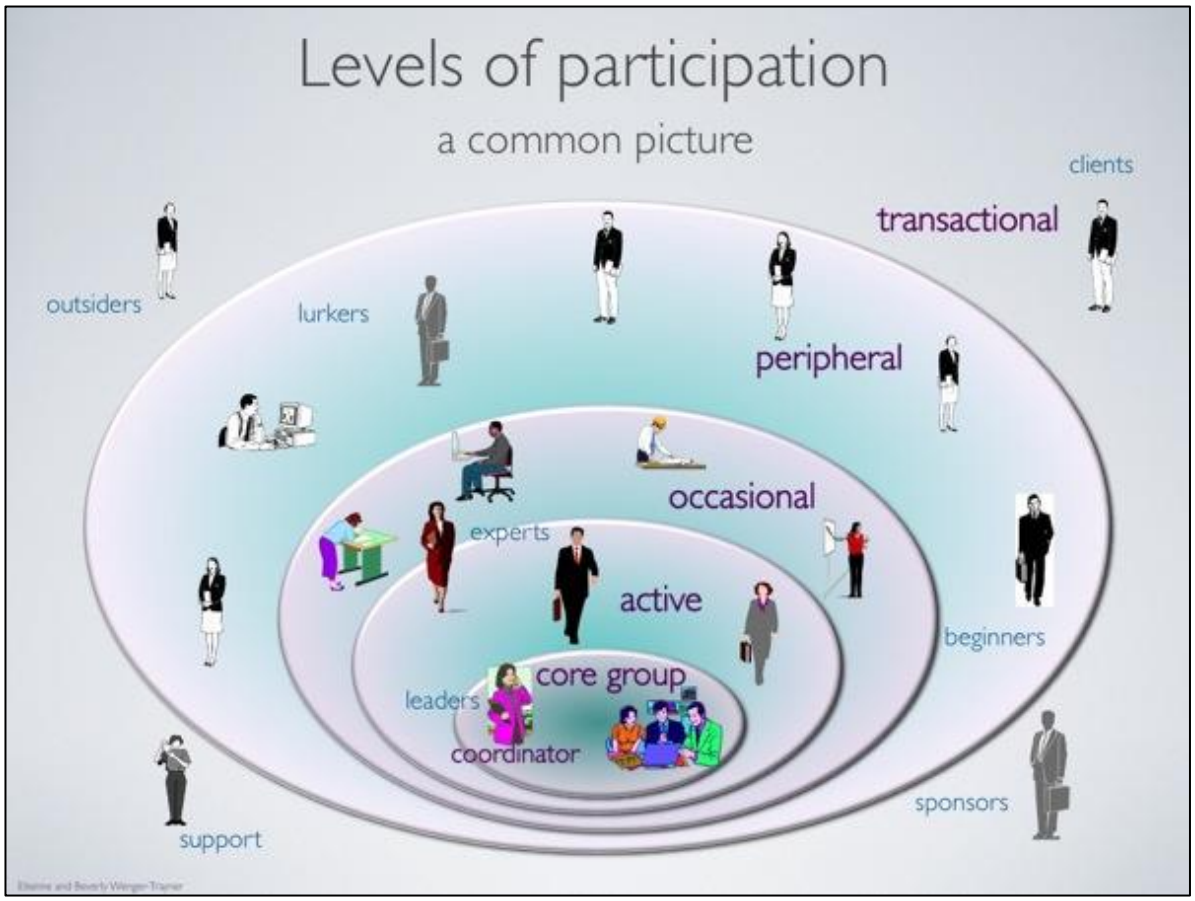

Figure 2. A Community of Practice (Wenger-Trayner, 2011)

Figure 2 provides an indication of what the structure of a CoP could look like but is missing representations of other structural components of a CoP such as trajectories, brokerage, boundaries, mutual exchange, etc. In contexts other than online learning, researchers have attempted structural investigations and visual representations of online CoPs with techniques

such as SNA, however, the attempts, at best, provide glimpses of the holistic structure and participatory dynamics (Chapter 4, Paper 2). Most existing studies on CoPs in HEOL do not provide practical implications of their findings revealing that the value of the CoP framework is yet to be realized (Smith, Hayes, & Shea, 2017). A reason for this is that research on CoPs has relied heavily on qualitative analysis of online data, interviews, surveys, documents, focus-group discussion, and observations. Due to the nature of qualitative analysis, the research has been tedious and time-consuming, majority of which has been conducted retrospectively. The value of retrospective research is restricted to such things as exploring effectiveness of learning designs, impact of different facilitation techniques, technologies, student attributes, etc. to inform future offerings of courses – a suggestion often made in further suggested research.

In summary, two key findings emerge from this discussion. Firstly, research on CoPs in HEOL has not paid much attention to the interactional or participatory (structural) component of the framework leaving our understanding of CoPs incomplete and secondly, the research demonstrates a lack of practical applicability of findings. Could it be then that the practical value of the CoP framework in HEOL lies in examining structural components of a CoP? If so, how can his be achieved?

2.4.2 The Community of Inquiry Framework

The Community of Inquiry (CoI) framework was developed by Garrison, Anderson and Archer (2000) as a guide for online learning practice and research and is used to inform methodologies and approaches to online learning design and delivery. Since its inception, the framework has been applied extensively in the HEOL context and remains in its original form.

2.4.2.1 Overview

The CoI framework rests on the practical inquiry (Dewey, 1938), socio-constructivist (Vygotsky, 1978) approach to learning in which knowledge construction is viewed as a *transaction* between individuals and social meaning making. This transactional perspective is grounded in the principle of subjective (personal) and objective (social) “interactions” of Dewey (1938) and “socially situated transactional” (Garrison, 2017, p. 10) views of Vygotsky (1978). As depicted in Figure 3,

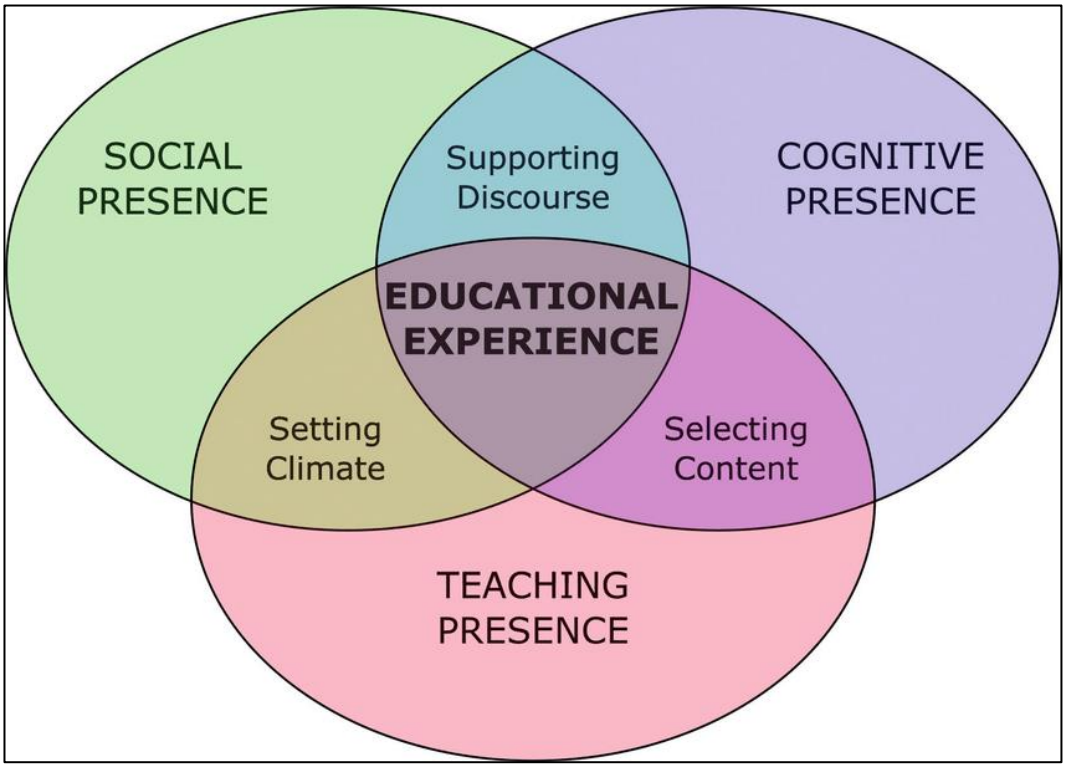

Figure 3. Community of Inquiry Framework (Dunlap & Lowenthal, 2018)

the CoI framework consists of three intersecting elements, namely, social presence (SP), cognitive presence (CP) and teaching presence (TP), each of which intermingle to create the educational experience.

In the context of online learning, a community forms when a group of individuals interact in the online space. A CoI forms when these interactions embed varying levels of each of the three presences. In a CoI, SP is defined as "the ability of participants in a community of inquiry to project themselves socially and emotionally as 'real' people…" (Garrison, Anderson, & Archer, 2000; p. 94). CP is "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse" (Garrison, Anderson, & Archer, 2001; p. 89), and TP is described as a presence that "manages the environment and focuses and facilitates learning experiences" (Garrison & Kanuka, 2004, p. 98). As shown in Figure 3., engagement or interactions with participants, content, and goals underly all other functionalities of SP, CP, and TP.

The CoI framework is a process model (Garrison, 2017) that situates learning at the intersection of SP, TP and CP all of which can be personified by anyone in the community. Each of the presences includes a sequence of categories or stages which intermix at different points in the

learning process, drive the process, and lead to deep learning experiences. Table 3 shows the different categories within each of the presence with sample indicators. Majority of the research on CoIs focuses on either one or two of the presences, SP being one of the most researched

Table 3

Community of Inquiry Categories and Indicators

Elements	**Categories**	**Indicator (examples only)**
Social presence	Personal/affective	Self-projections/expressing emotions
	Open communication	Learning climate/risk-free expression
	Group cohesion	Group identity/collaboration
Cognitive presence	Triggering event	Sense of puzzlement
	Exploration	Information exchange
	Integration	Connecting ideas
	Resolution	Applying new ideas
Teaching presence	Design and organization	Setting curriculum and methods
	Facilitating discourse	Shaping constructive exchange
	Direct instruction	Focusing and resolving issues

Source: Garrison (2017, p. 28)

followed by TP and CP. More research is needed on the inter-relationships between the three presences over time (Garrison, 2017, p. 79). What is known about the relationships between the presences is that SP is the underlying presence in a CoI. In a review of research on the CoI framework, Garrison and Arbaugh (2007) report that SP forms the foundation of CP and within CP, while students are able to get through the first two stages (triggering event and exploration), TP is needed for the completion of the last two stages (integration and resolution). Other research findings report that SP leads to greater group cohesion and productivity (Rogers & Lea, 2005) and plays a mediating role between CP and TP (Shea & Bidjerano, 2010; Joksimovic, Gasevic, Kovanovic, Riecke & Hatala, 2014). It has also been suggested that even though SP plays a significant role in a CoI, all three presences should be considered jointly as there is a need to balance the level of each presence. For instance, Jahng, Nielsen and Chan (2010) found that an optimal level of SP might be required to support collaborative inquiry without negatively impacting the academic purpose of the community. With reference to the role of TP, TP is found to support CP especially in the last two stages (Rourke & Kanuka, 2009), the design and nature of the task being the greatest factors in reaching resolution (Alavi & Taghizadeh, 2013). TP is crucial to ensure participation and quality of responses (An, Chin & Lim, 2009). In terms of influence on CP, TP along with SP, specifically, facilitation and direction, are associated with integration and resolution of tasks (Bangert, 2008). Again, it has been suggested that the right balance between

the presences is required as too much TP can hinder participation and knowledge construction (Zhao & Sullivan, 2016).

As stated earlier, the relationships between SP, TP, and CP are under-researched. Regardless of the dynamics between the presences, the formation of a CoI assumes that online interactions are taking place between participants. These interactions make the community cohesive depending on the degree of interactions. Without the cohesiveness, TP and CP are unable to develop and diffuse across the community. Group cohesion signifies SP which is therefore always present in a CoI (Garrison, 2017). Thus, SP can be viewed as the foundation of a CoI upon which TP and CP develop over time. Furthermore, in a cohesive and vibrant CoI which assumes a balanced distribution of the presences across the community, one would expect SP (interactions) to be equally dispersed as well. It is difficult to visually re-conceptualize SP as the omnipresent presence in a CoI in Figure 3, however, as it is, the figure does not reflect the underlying configuration of a CoI with SP as its foundation. Such a re-conceptualization calls for viewing a CoI from a structural perspective. Whether and how that is possible remains to be seen.

2.4.2.2 Applying and Researching the CoI Framework in HEOL

The CoI framework is one of the most widely cited and used frameworks and has empirically proven to be effective in explaining individual and collective learning in traditional and online contexts (Shea & Bidjerano, 2010). The framework has been reported as "the most frequently used theoretical perspective" in research on e-learning between 2009-2013" (Bozkurt et al., 2015, p. 344) and "seems to be one of the most utilized theories for blended learning…" (Halverson, Graham, Spring, Drysdale, & Henrie, 2013, p. 24).

While the relationships between the three presences are unclear and require further research (Garrison, 2017), there is abundant research on the positive impact of SP, TP, and CP on such things as student retention, satisfaction, motivation, and performance. For instance, SP has been positively linked with academic performance (Yang, Quadir, Chen, & Miao, 2016), satisfaction (Leong 2011); perceived learning (Capsi & Blau, 2008) and, student retention (Boston et al., 2009; Ice et al., 2011). TP has been shown to positively impact perceived learning and satisfaction (Akyol & Garrison, 2010; Yang et al., 2016, Ice et al., 2011; Khalid & Quick, 2016), achievement of intended learning outcomes (Szeto, 2015), and completion of learning tasks (Ma, Han, Yang & Cheng, 2015). CP has been linked with perceived and actual learning outcomes (Lim, Morris &

Kuprtiz, 2007; Roblyer et al., 2007), satisfaction and retention (Ice et al., 2011). Note that much of the research on CoIs has used perceived learning as a proxy measure for actual learning as it is difficult to measure the quality of learning outcomes, therefore, the relationship between CP and actual learning outcomes needs further exploration (Garrison, 2017). Overall, learning in a CoI is expected to result in better learning outcomes for students (Rockinson-Szapkiw, Wendt, Wighting, & Nisbet, 2016; Warner, 2016).

From 2001 until 2008, research on CoIs has relied on extensive qualitative analysis of online discourse transcripts between participants. In 2008, with the development of the CoI survey (Arbaugh, et al., 2008), a mix of qualitative and quantitative analysis has been used for investigating CoIs. Note that survey-based data can be influenced by such things as participant recall, response bias, characteristics of the respondents, misunderstanding of survey questions, etc. (Robson, 2002) as opposed to factual and reliable data which is obtainable from LMSs. Cognizant of the value of actual online data, more recently, researchers have complemented qualitative analysis with techniques such as SNA. However, the application of SNA has been limited (Jan, Vlachopoulos, & Parsell, 2019 [Chapter 3]). Due to the time taken to conduct qualitative analysis, to date, research on CoIs has been retrospective and therefore appears to lack immediate practical value. Findings from retrospective research on CoIs have effectively informed the design including facilitation of online learning environments. However, given that a CoI is described a process model, its real value lies in an ongoing assessment of and intervention in the process allowing for formative diagnostics, timely intervention (Garrison, 2017), and response to emergent conditions (Bower, 2017), all of which are needed to cultivate a CoI. In his recent book, *E-Learning in the 21st Century*, Garrison (2017) acknowledges the need for research methodologies that would enable such ongoing analytics stating, “there is a need to refine research methodologies for effective assessment of things within a CoI such as group cohesion, inquiry progress and direction” (p. 165). Clearly, qualitative and survey-based research have limitations due to the time and effort required. Without examining the content of online transcripts, the presences in a CoI cannot be quantified. As in the case of CoPs, little attention has been paid to the overall structure of a CoI even though researchers have used SNA to explore the relationships between the presences in a CoI (Jan, Vlachopoulos, & Parsell, 2019 [Chapter 3]). Going back to the re-conceptualization of SP as the foundation of a CoI upon which TP and CP develop, could it be that the immediate practical value of a CoI lies in its structural exploration?

2.4.3 Conclusion

This chapter started off with establishing the historical significance of learning communities. Following this, major pedagogical foundations of community-based learning were discussed leading up to the development of the CoP and CoI frameworks. Both frameworks were then reviewed with an emphasis on the role of interactions and structural aspects of each. An overview of existing literature on the CoP and CoI frameworks in HEOL was provided which highlighted the lack of attention to interactional or structural components and lack of immediate practical value of the frameworks in existing research. Given the limitations of research methodologies (time consuming, qualitative analysis of retrospective data) commonly used to investigate CoPs and CoIs in HEOL, the lack of immediate practical value does not come as a surprise. What does come as a surprise is the finding that, given that networks of interactions (engagement or participation) form the underlying structure of communities (as discussed in Chapter 1), to date educational researchers, especially those interested in SNA, have not considered what the structure of a CoP and CoI might look like visually and how this visualization can aid in assessing ongoing community formation and evolution. Should it be possible to visually and quantitatively identify a CoP and CoI based on the overall structure of a community, the immediate practical value of the frameworks could potentially be cultivated. To achieve this, two things are required: ongoing interactional data and a methodology that allows timely identification of CoPs and CoIs based on their unique structural characteristics. The first of the two, that is, ongoing interactional data, is available from LMSs. The second, being the key driver of this research, is the subject of the following chapters.

3. Chapter III: Social Network Analysis and Learning Communities in Higher Education Online Learning: A Systematic Literature Review (Paper One)

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http://dx.doi.org/10.24059/olj.v23i1.1398

Foreword

In the previous chapter, I established the pedagogical significance of, need for and a gap in the structural understanding of CoPs and CoIs. I also mentioned that researchers have previously attempted to explore certain structural aspects of CoPs and CoIs with SNA which points to the suitability of the technique for such an investigation. In this chapter, I present the first of two systematic literature reviews which I undertook as a scoping exercise to explore if and how SNA has been previously integrated with the CoP and CoI frameworks to structurally explore CoPs and CoIs. I conducted the review with the objective of obtaining guidelines for developing a theoretically grounded framework for structurally (visually and quantitatively) investigating and identifying CoPs and CoIs in HEOL. To ensure high quality of the guidelines extracted, I restricted the database searches to peer-reviewed journal articles which have undergone rigorous review. I undertook and wrote this review in the first year of my candidature however, it was published last which turned out just as well since I got the opportunity to re-run the database searches and update the review prior to publication. I, being the first author of the paper, independently conducted majority of the work for the review including database searches, study selection, consolidation of findings and writing. My supervisors provided valuable direction and feedback to me which greatly enhanced the quality of the final publication and are therefore included as co-authors.

3.1 Abstract

This paper presents the results of a systematic literature review which sets out to explore the use of social network analysis (SNA) for investigating learning communities specifically, communities of practice (CoP) and community of inquiry (CoI) in higher education online learning (HEOL). The impetus for such a review originated from the reliance on extensive and time-consuming qualitative analysis typically required in research involving the CoP and CoI frameworks. The review consolidates and synthesizes existing research in HEOL in search of a methodological framework for structurally evaluating a CoP and/or CoI using SNA. We identified a handful of studies that integrate SNA measures and key structural components of the CoP and CoI frameworks and examined: SNA measures and corresponding theoretical components used; other analytical techniques used; limitations and; suggestions for further research. The selected studies reported disparate findings in terms of the relationship between SNA measures and the CoP and/or CoI components. The review also highlighted the need to complement SNA with a qualitative analytical technique. Therefore, whether SNA has the potential to be used as a stand-alone technique for structurally identifying communities remains to be seen. We also find a lack of consideration to attributional and performance variables in existing studies. In conclusion, we propose further research and the development of a fully integrated methodological framework which uses SNA to structurally evaluate a CoP and CoI.

3.2 Introduction

The adoption of online learning[1] by progressive number of institutions (Allen, Seaman, Poulin, & Straut, 2016) has necessitated and accelerated research into pedagogical practices in the online space. A large amount of research on online learning draws from Vygotsky's (1978) social constructivist theories of learning (Smith, Hayes, & Shea, 2017) rooted in Dewey's (1938) concept of student-driven learning through engagement, active learning and collaboration, the pedagogical foundations of learning communities. The importance of learning within communities rests on decades of research dating back to the 1920s (Smith, 2001). Following a relatively quiet period, the community learning idea re-emerged in the mid-1990s when several studies were published associating learning within a community with positive outcomes for

[1] [1] The terms "online learning" and "e-learning" include purely online and blended courses and have been used inter-changeably where necessary.

university students (Zhao & Kuh, 2004). In 1991, drawing from Dewey and Vygotsky's social constructivist ideas, Lave and Wenger (1991) proposed the situated learning theory which describes learning as a social process situated within a community of practice (CoP). As online learning gained momentum in the early 1990s, learning in communities became the holy grail of online learning as evidenced by the view that "without the support and participation of a learning community, there is no online course" (Paloff & Pratt, 1999, p.29). Onwards, the introduction of social learning technologies and collaborative learning further propelled the community learning movement. In 2000, also rooted in social constructivist and situated learning perspectives, Garrison, Anderson and Archer (2000) developed the community of inquiry (CoI) framework as a model for online teaching, learning and research.

Both the CoP and CoI frameworks address learning within the structure of a community grounded in a network of relationships and have been commonly applied to research on networked learning (Conole, 2011) however, majority of the research involving the frameworks is qualitative and time-consuming as it relies on extensive content analysis of online communication transcripts (Garrison, 2017; Wenger, McDermott, & Snyder, 2002). The development of the CoP framework was rooted in the context of professional learning whereby novices in a community learn from and gradually evolve into experts themselves whereas the CoI framework was specifically developed as a guide for online pedagogy and research. Interactions and the nature of these interactions within networks of learners is the basic underlying concept in both a CoP and CoI however since the communities are conceptually distinct, the structure of the networks underlying the communities is expected to be unique. The question then arises, can structural differences be used to evaluate and identify a CoP and CoI? At this point, a clarification between a network and a community and the relationship between the two is warranted. A network is simply defined as "a set of connections among people…" used for solving problems, sharing knowledge, and making more connections (Wenger, Trayner, & De Laat, 2011, p.9). Alternatively, a community is "a group of individuals identifiable by who they are in terms of how they relate to each other, their common activities and ways of thinking, and their beliefs and values" (Biza, Jaworski, & Hemmi, 2014, p.162). A network provides the social structure underpinning a community while a community provides the social mechanism through which knowledge is generated within a network. A community is a network however a network is not necessarily a community (Wenger, 1998). Social network analysis (SNA), a quantitative analytical technique, has commonly been used to analyse and visualize networks.

SNA is an interdisciplinary technique for investigating relationships between entities or nodes in a network. SNA distinguishes itself from other analytical approaches as it: allows for visual representation of data; emphasises relations between nodes as opposed to individual attributes (Freeman, 2006); examines activities of nodes influenced by the structure of the relational networks (Wasserman & Faust, 1994); studies the flow of resources or information between nodes (Wasserman & Faust, 1994) and; can be applied at the individual (micro) and/or aggregate (macro) level (Borgatti, Everett, Martin, & Johnson, 2013). The history of SNA dates back to the 1930s (Moreno, 1953) however it was not until 1954 that the term 'social network analysis' was formalised into a theoretical perspective including concepts from graph theory, statistics, and probability. SNA has been used to study complex social interactions in various fields for instance, healthcare (Chambers, Wilson, Thomson, & Harden, 2012), communication (Haythornthwaite, 1996), education (Aviv, Erlich, Ravid, & Geva, 2003), economics (Granovetter, 2005) political science (Ward, Stovel, & Sacks, 2011), and engineering (Senghore, Campos-Nanez, Fomin, & Wasek, 2014).

SNA is being increasingly applied to the field of higher education online learning (HEOL) primarily due to the availability of big data, that is, large amounts of data stored in institutional learning management systems (LMS) (Picciano, 2012). In the context of HEOL, nodes in the network represent students, lecturers or tutors and the connections indicate online interactions within the LMS. SNA falls under the realm of social learning analytics, a category of learning analytics defined as the "measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (LAK, 2011, para.6). Numerous studies have used SNA to investigate various aspects of e-learning (Cela, Sicilia, & Sanchez, 2015). Cela et al. (2015) identified a total 37 studies published between 1999 to 2012 using SNA in e-learning contexts. Topics examined included interactional analysis, effectiveness of specific technologies, identification of group structures and, the roles of students, lecturers, and tutors. Despite this upsurge, the field of learning analytics is in its infancy (Avella, Kebritchi, Nunn, & Kannai, 2016) as the potential and pedagogical value of techniques such as SNA has yet to be fully realized.

The intricate relationship between networks and communities, structural parallels between the two, and access to retrospective and real-time big data from LMSs, make SNA the ideal technique

for structurally investigating a CoP and CoI in HEOL. This systematic review aims to find out if this has been done before and if so, how? The key objective of the review is to synthesize and evaluate literature that investigates a CoP and CoI using SNA and therefore establish the availability or lack of an integrated methodological framework for structural identification of learning communities. Specific research questions guiding the review are listed in the review protocol below. Prior to presenting the systematic review and our findings, in the following section we present an overview of the CoP and CoI frameworks with an emphasis on the structural components of each.

3.3 Theoretical Frameworks

3.3.1 Communities of Practice

Lave and Wenger (1991) introduced the theory of situated learning which postulates that learning takes place in a social context where knowledge is constructed collectively. They presented the seminal idea of legitimate peripheral participation, a process by which newcomers enter a group and eventually evolve into experts by learning and adopting practices of the group. This cyclical activity signifies learning as it leads to the development of individual and collective identities through the processes of participation and reification. Wenger (1998) discusses three aspects of practice that define a CoP: mutual engagement; joint enterprise; and shared repertoire. Mutual engagement refers to interactions between participants that leads to the construction of common meaning through negotiation. Joint enterprise refers to the process of mutual engagement and actions towards achieving a shared goal. Shared repertoire refers to the common resources and terminology used within the community. Wenger (1998) conceptualizes identity as a mode of belonging to a CoP via engagement, imagination, and alignment (p.173). Wenger, McDermott, and Snyder (2002) revise the three aspects of a CoP to domain, community, and practice where the domain is the common ground which defines the identity of the group, the community is the web of social relationships and, the practice is the shared repertoire of resources. In Wenger, White and Smith (2009), the role of technologies in CoP is brought to focus with the introduction of the idea of a digital habitat. The key to a sustainable thriving digital habitat is to find the right balance between three inherent polarities which drive communities to adopt technologies. These polarities include: rhythms (togetherness and separation); interactions (participation and reification); and identities (individual and group).

Even though the CoP framework has evolved over time, interactions between members of the community remain at the crux of the framework. To reiterate, reification requires participation (Wenger, 1991), negotiation of meaning comes from mutual engagement which leads to a sense of belonging (Wenger, 1998), a CoP is embedded in a network of social relationships (Wenger, McDermott, & Snyder, 2002), and finally the rhythms of togetherness and separation, and participation and reification sustain a CoP (Wenger, White, & Smith, 2009). Thus, even though a structural investigation alone of the underlying network of the community does not allow for a holistic evaluation of a CoP, we believe it can provide critical insight into community dynamics.

3.3.2 Communities of Inquiry

The CoI framework was developed by Garrison, Anderson, and Archer (2000) as a guide for online learning practice and research and is used to inform methodologies and approaches to online learning design and delivery. It consists of three intersecting elements namely, social presence (SP), cognitive presence (CP), and teaching presence (TP). SP is defined as "the ability of participants in a community of inquiry to project themselves socially and emotionally as 'real' people…" (Garrison, Anderson, & Archer, 2000, p.94). CP is "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse" (Garrison, Anderson, & Archer, 2001, p.11). TP "manages the environment and focuses and facilitates learning experiences (Garrison & Kanuka, 2004, p.98) and is not specific to the tutor hence the use of the term teaching as opposed to teacher presence (Vlachopoulos & Cowan, 2010). Each presence includes a sequence of stages, the interactions of which at different instances in the learning process propel the process forward and lead to deep learning experiences. For instance, within CP, while students can get through the first two stages (triggering event and exploration), TP is needed for the completion of the last two stages (integration and resolution) thereby suggesting a complementary relationship between TP and SP (Garrison & Arbaugh, 2007). Research also shows that there is a strong relationship between SP and learning outcomes (Hwang & Arbaugh, 2006) and that SP forms the foundation of CP (Garrison & Arbaugh, 2007) and mediates between TP and CP (Garrison, 2017). Post a series of empirical studies (Shea & Bidjerano, 2010; Shea et al., 2012; Shea et al., 2013) Shea and colleagues proposed the inclusion of a new construct, that is, learning presence (LP) in the CoI framework.

Garrison (2017) provides a comprehensive account of the research and developments in the CoI framework to date acknowledging the need for further exploration and validation. In terms of

structural evaluation of a CoI, since SP is the underlying presence of CP and TP, SP is always present in a CoI. SP is represented by group cohesion or the level of interactions between participants (Garrison, 2017). Therefore, the overall density and distribution of interactions of the network underlying a CoI represents the distribution of SP and potentially CP and/or TP. Hence, we believe that the first step in an assessment of a CoI must include examination of the configuration of interactions (SP) between participants.

3.4 The Systematic Review Process

3.4.1 Research method

"A systematic literature review is a means of identifying, evaluating, and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest" (Kitchenham, 2004, p.1). A systematic review is different from a traditional literature review in that it is follows a scientific methodology and should be replicable (Staples & Niazi, 2007). The overall structure of this review follows Kitchenham's (2004) guidelines which have been adapted to the educational context as has been done before (Cela et al., 2015). As per the guidelines, we begin by identifying the need for the review. Then we present the review protocol which includes the scope and research questions. Next, we describe identification of research studies including the database searches and study selection criteria and process. Finally, we synthesize and report our findings.

3.4.2 Identifying the need for a systematic review

Prior to conducting a systematic literature review a search should be undertaken for any existing relevant reviews that might address the subject under review thereby eliminating the need for the review (Staples & Niazi, 2007). At the time the original database searches were conducted in March 2017, we found one prior systematic literature review on SNA in e-learning (Cela et al., 2015) which mentions two other previous reviews (Sie et al., 2012; Zhao, Zhu, & Wu, 2011) on SNA. A re-run of the database searches in May 2018 identified another literature review (Dado & Bodemer, 2017) that examines trends in the application of SNA for investigating learner interactions in computer-supported collaborative learning environments. None of the reviews make any mention of the CoP and/or CoI frameworks. Literature reviews on CoP (Smith et al.,

2017) and CoI (Rourke & Kanuka, 2009) also make no mention of the studies that use SNA as a key analytical methodology.

3.4.3 Review protocol

3.4.3.1 Defining the focus of the review

The most critical component of a systematic literature review is the research questions driving the review as they define the boundaries of the review and impact the inclusion criteria for studies (Staples & Niazi, 2007). This review was conducted to address the following research questions:

RQ1: Are there any research studies in HEOL that employ SNA to investigate a CoP and CoI?

RQ2: Which SNA constructs have been used to explore components of a CoP and CoI?

RQ3: What other complementary analytical techniques have been used with SNA?

RQ4: How effective is SNA for investigating and identifying a CoP and CoI?

RQ5: What limitations have been identified and what suggestions for further research have been made in existing studies?

3.4.3.2 Searching literature databases

Database searches were conducted in March 2017 and again in May 2018 in EBSCOhost, SCOPUS, and ERIC. SCOPUS is considered to be the largest database of peer-reviewed research literature, ERIC is one of the most used databases for educational-related literature and, the EBSCOhost platform includes numerous databases across multiple disciplines. The search criteria consisted of combinations of different terms to ensure maximum coverage of variations in usage (see Table 4). The search was conducted on the full text of documents and was limited to peer-reviewed, journal articles and conference proceedings in English. No lower limit on the year of publication was specified.

Table 4	
Database search terms	
Term	**Variations**
Online Learning	e-learning OR elearning OR online learning OR blended learning
Community	community OR communities
Community of Practice	community of practice OR communities of practice
Community of Inquiry	community of inquiry OR communities of inquiry
Higher Education	undergraduate OR graduate OR postgraduate OR bachelors OR masters OR higher education
Social Network Analysis	social network analysis

3.4.3.3 Study selection

The search process began with specifying broad criteria which were progressively narrowed down to include studies in HEOL that use SNA methodology as an analytical tool and use CoP and/or CoI as key frameworks for analysis. Table 5 below shows the different stages of the study selection process. The numbers shown in the table represent studies in HEOL as this was applied as an umbrella criterion for the searches. Stage 1 of the search returned a total of 17,044 studies in HEOL mentioning the term 'community'. In stage 2, the search criteria were further narrowed to include 'social network analysis' returning a total of 561 studies. In stage 3, the criteria were again narrowed, and two separate searches were conducted to include 'community of practice' and 'community of inquiry' returning a total of 191 studies mentioning CoP and SNA and 102 studies mentioning CoI and SNA. In stage 4, bogus results and duplicates were removed. In stage 5, with the assumption that studies using SNA as an analytical methodology would mention the term 'network analysis' in their abstracts, the abstracts of the remaining 180 CoP studies and 98 CoI studies were searched for the term. Finally, 37 CoP studies and 29 CoI studies were selected for a detailed review. Upon detailed review, of the 37 studies using SNA and the CoP framework, 19 were either not using SNA or were not in HEOL, 6 only mentioned the CoP framework, 1 was a literature review, and 10 were duplicates of the CoI studies. Therefore, finally only 1 study met the inclusion criteria. Of the 29 studies using SNA and the CoI framework, 7 were not in HEOL, 12 only mentioned the CoI framework and, 1 was literature review. Therefore, finally 9 studies met the inclusion criteria. There are many examples of the application of SNA on the use of social

media in online learning (e.g. Veletsianos & Kimmons, 2016). All such studies have been excluded from the review as our focus is on formal and structured learning within a LMS.

Table 5

Study selection process

		Search Parameters		
	Stage 1	**Stage 2**	**Stage 3**	
Databases	**Community**	**Community & SNA**	**CoP & SNA**	**CoI & SNA**
SCOPUS	12,712	441	126	83
EBSCO Host	2,247	11	2	1
ERIC ProQuest	2,085	109	63	173
Total	**17,044**	**561**	**191**	**102**
	Stage 4	**Bogus results & Duplicates**	12	5
	Stage 5	**Remaining Studies**	180	98
		Abstracts searched for SNA	37	29

3.4.3.4 Other searches

To extend the scope of the search, references of the selected studies were reviewed. Additionally, the citation index of the studies was obtained using Google Scholar (https://scholar.google.com.au). Upon review, none of the studies citing the selected studies met the inclusion criteria. Furthermore, selected authors were contacted for further information. No additional studies were identified.

3.4.4 Results of the systematic review

3.4.4.1 RQ1: Are there any research studies in HEOL that employ SNA to investigate a CoP and CoI?

Table 6 lists the studies included in this systematic review. Each study has been assigned a number for ease of reference going forward. A detailed summary of the studies is provided in Appendix A.

Table 6

SNA and CoP/CoI studies

No.	Author(s)	Year	Framework	Title
S1	Shea & Bidjerano	2010	CoI	A re-examination of the community of inquiry framework: Social network and content analysis
S2	Annese & Traetta	2012	CoP	Distributed participation in blended learning communities: Actors, contexts, and groups
S3	Jimoyiannis, Tsiotakis, & Roussinos	2012	CoI	Blogs in higher education: Analysing students' participation and presence in a community of blogging
S4	Shea et al.	2013	CoI	Online learner self-regulation: Learning presence viewed through quantitative content- and social network analysis
S5	Shea et al.	2014	CoI	Re-conceptualizing the community of inquiry framework: An exploratory analysis
S6	Tirado, Hernando, & Aguaded	2015	CoI	The effect of centralization and cohesion on the social construction of knowledge in discussion forums
S7	Wicks et al.	2015	CoI	An evaluation of low versus high collaboration in online learning
S8	Jimoyiannis & Tsiotakis	2017	CoI	Beyond students' perceptions: Investigating learning presence in an educational blogging community
S9	Jo, Park, & Lee	2017	CoI	Three interaction patterns on asynchronous online discussion behaviours: A methodological comparison
S10	Satar & Akcan	2018	CoI	Pre-service EFL teachers' online participation, interaction, and social presence

Of the 10 studies, all except 1 (S2) were conducted in the context of the online space of online or blended courses. S2 explored online and off-line interactions. The studies investigated interactions within asynchronous discussion forums (S1, S2, S4, S5, S6, S9, S10), blogs (S3, S7, S8) and journal entries (S4). All investigations were conducted on interactions between students and/or tutors. The key objective of each study guided the scope and nature of analysis undertaken. S1 was conducted an examination of the relationships between CP, SP and TP; S2 investigated the impact of learning design on participation in a CoP; S3 analyzed student participation in terms of CP, SP and TP; S4 conducted an exploration of LP and network positions

and the effects on the same of assigning instructional roles to students; S5 investigated relationships between LP and CP, SP and TP and explored the impact of assigning instructional roles to students; S6 developed a model to verify the influence of cohesion and centralization on the quality of the learning process; S7 investigated the impact of student collaboration on student performance; S8 developed an integrated framework for designing and investigating engagement patterns and LP; S9 conducted a comparison of three analytical methodologies to assess the quality of online discussions and their relationship with academic performance and; S10 examined the relationship between online participation, interaction, and SP levels.

3.4.4.2 RQ2: Which SNA constructs have been used to explore components of a CoP and CoI?

Network properties

A network is made of nodes and interconnections between them (Wasserman & Faust, 1994). A one-mode network comprises of a single set of nodes connected by single or multiple types of relationships. A two-mode network consists of two sets of nodes, that is, actors and events (Scott, 2000). All included studies were on one-mode networks. Nodes in a network can represent human and/or non-human entities. All included studies comprised of human entities where the nodes represented students only (S2, S3, S4, S5, S6, S7, S8, S9) or students and tutor (S1, S10). The number of nodes determine the size and boundaries of a network (Wasserman & Faust, 1994). Of the 10 studies, 3 studies (S2, S4, S5) had less than 25 nodes, 5 studies (S3, S6, S7, S9, S10) had between 35 to 75 nodes and 2 studies (S1, S9) did not specify the number of nodes.

A tie or link between nodes in a network represents the relationship between the nodes which can be of any type, for instance, co-workers, friends, professionals, etc. (Wasserman & Faust, 1994). The direction of a tie identifies the initiator of the relationship, a bi-directional tie represents a reciprocal relationship while the weight of a tie signifies the strength of the relationship (Borgatti et al., 2013). The ties in the selected studies represented interactions between students and/or tutors or lecturers. Of the 10 studies, 8 used directed and un-weighted networks. The networks in S6 and S10 were directed and weighted.

SNA, CoP and CoI constructs

Majority of the studies used similar SNA measures. Here we discuss the key SNA measures used along with corresponding structural components of a CoP and CoI. For a detailed analysis, see Appendix B.

A network can be measured in terms of its shape and cohesion. Determinants of cohesion include a networks' centralization, density, and number and size of cliques. Centralization, a shape measure, is defined as the degree to which a single node dominates a network (Borgatti et al., 2013). In S6, the network's centralization is used as a measure of collective communication and overall cohesion of a CoI, while S10 interprets centralization in terms of the existence of SP in the CoI. Density, which is calculated by dividing the total number of ties in a network by the total number of possible ties, is a proportion therefore, it allows for comparison of networks regardless of size assuming the size differential is not huge (Borgatti et al., 2013). In S1 and S10, density is taken as an indicator of SP, S6 and S9 use density to assess rate of participation in a CoI and, S2 uses the measure of density to assess the participation trajectory of the CoP.

In a large complex network, often there are nodes within sub-groups that have a higher density of connections that warrant detailed analysis as independent entities. These sub-groups are called cliques. A clique is a group of nodes in which every node is adjacent to every other node in the group, that is, it is a maximally connected sub-network with a density of 1. S3 and S8 use clique analysis to investigate the overall architecture of a CoI taking the number and composition of cliques as determinants of the process of knowledge creation and extent of communication. S2 examines cliques to assess the development of the CoP and individual learning trajectories. Cliques can overlap which means a node can belong to multiple cliques and there can be nodes that do not belong to any clique (Borgatti et al., 2013). Nodes belonging to multiple cliques are considered as bridges or brokers. S2 uses clique analysis to identify brokers and assess local and global interactions within and across sub-groups.

The centrality of a node refers to the structural position of the node in a network. The simplest measure of centrality is degree centrality which is the number of connections of a node. In a directed network, the in-degree centrality measures the incoming edges and the out-degree centrality represents outgoing edges. The centrality of a node has also been linked to power, influence, prestige, and performance (Borgatti et al., 2013). In-degree centrality and out-degree centrality were used as indicators of influence and prestige (S1, S5) linked to CP, TP and CP and LP (S4, S5, S7) in a CoI. Overall degree centrality was used to signify status and roles in a CoP (S2) and power in terms of spreading information and influencing others in a CoI (S3, S8).

Summarizing, we have found that at the whole network level, measures of cohesion have dominated the structural evaluation of a CoP and CoI and at the individual node level, measures of degree centrality have been prominent.

3.4.4.3 RQ3: What other complementary analytical techniques have been used with SNA?

Other complementary techniques used in the studies include content analysis, critical discourse analysis and statistical analysis like correlations, multiple regressions, non-parametric tests of significance and structured equation modeling. Content analysis is a qualitative and quantitative analytical technique used to conduct an in-depth analysis of discussion transcripts enabling standardized interpretations and classifications of text according to a specific coding scheme (De Wever, Schellens, Valcke, & Van Keer, 2006). Critical discourse analysis is a special technique grounded in critical linguistics and critical semiotics, used to examine written text and the language, discourse, or communication within the text (Van Dijk, 1995). A list of complementary techniques used by each study are listed in Appendix B. Clearly, to date, SNA has not been used as a stand-alone technique in the investigation of a CoP or CoI.

3.4.4.4 RQ4: How effective is SNA for investigating and identifying a CoP and CoI?

The overall objective of this systematic review which was to tease out how structural components of a CoP and CoI have been researched using SNA. To assess the effectiveness of SNA for investigating a CoP and CoI, a synthesis of findings from the studies follows.

Community of inquiry

Four of the CoI studies examined SNA indicators of CP, TP and SP and the relationship between the presences. In an exploration of the relationship between CP, SP and TP in an online discussion forum, S1 found in-degree to be a poor indicator of CP specially when applied to the tutor. In other words, incoming comments to the tutor were not of educational value. However, the out-degree centrality of the tutor was associated with initiation of productive exchange, a category of CP. The study reported density to be a good indicator of SP. In line with findings of S1, S6 found SP to be more prominent as compared to CP in an online discussion forum. However, structured equation modeling showed a positive relationship between network centralization and SP as well as CP. Similarly, in an online blogging community, S3 found a positive association between CP, knowledge construction, and active participation in the community. In this instance, CP was

found to be higher than TP and SP. S10 reported inconclusive findings on the relationship between centrality, density, and SP in an online discussion forum. In a methodological comparison, S9 found combined CP and in-degree centrality to be a significant predictor of academic performance thereby corroborating the positive relationship between the two.

Four of the CoI studies explored the construct of LP and its' relationship with degree centrality and CP, SP, and TP. For instance, in a discussion forum, S4 found that key student facilitators with high degree centralities exhibited higher levels of LP. In general, findings suggested that students with high LP also had high in-degree implying that they were considered valuable sources of information by other students. In a follow-up study which investigated the relationships between LP and CP and SP and TP, S5 found no significant correlation between TP and degree centrality however, LP and CP and LP and degree centrality were positively associated with degree centrality. Similarly, S8 applied hierarchical clustering to group similar students and found an association between degree centrality and LP in an online blogging community. Likewise, investigating the impact of collaboration on learning, S7 reported a positive correlation between LP and out-degree and a negative correlation between LP and in-degree. Findings of these studies point to a positive relationship between LP and degree centrality however, at this point there is not enough published research to validate the construct of LP and its relationship with the other three presences.

Considering that the 9 CoI studies report disparate findings in terms of the relationship between degree centralities and CP, SP and TP, SNA's capacity to identify the type of presence based on overall and in and out-degree centralities of participants of a CoI cannot be established. However, if SP is the underlying presence in a CoI which gradually evolves into CP and TP over time (Garrison, 2017), it is reasonable to assume that the density of network and overall degree centrality of a node is indicative at least of SP upon which TP and CP develop.

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Communities of practice

S2 presents findings of action research on the impact of learning design on student participation and collaboration in a blended course. The researchers base their analysis on a comparison of individual and group participation trajectories within sub-group (local) and whole network (global) interactions. They use measures of density and cohesion as indicators of the global trajectory of the community. For individual trajectories, degree centralities and the number and

structure of cliques is analyzed where overlapping cliques represent overlapping CoP. At the same time, the status and role of brokers and bridges is considered within the local and global community. In their discussion of the findings, the researchers place emphasis on the rhythm between local and global interactions and the effect of this rhythm on the sense of belonging to individual sub-groups and the whole community. The researchers attribute the online togetherness to the mediating role played by the technological artefact, the LMS, which brings students together. The researchers conclude that the design of the course led to the development of a CoP without spatial or temporal boundaries in which the rhythms of participation amplify the shared repertoire and sustain the mutual engagement and joint enterprise as indicated by an increase in global cohesion over time. S2 provides a very good, albeit only one, example of how SNA can be effectively used to investigate structural components of a CoP in HEOL. This example, coupled with the fact that SNA has been used considerably in conjunction with the CoP framework in other contexts (e.g. Grandjean, 2016; Lee, Kim, & Su, 2014) leads us to conclude that SNA can be used effectively in a structural evaluation of a CoP.

3.4.4.5 RQ5: What limitations have been identified and what suggestions for further research have been made in existing studies?

Even though the sample size of majority of the studies is small, only two studies (S5, S6) explicitly state it as a limitation. More specifically, several studies (S1, S2, S3, S6, S8, S10) point out the need to investigate the role of tutors/facilitators and its' impact on participation dynamics. Another important suggestion for further research (S3, S8) is the need to explore the influence of student characteristics like cognitive needs, goals, learning habits, and motivation on participation. Other suggestions include focusing on a specific part of the learning process, for instance, the role of a technological artefact (S2), extending analysis to off-line interactions for blended units (S8, S10), identification of variables in discussion transcripts that are indicative of quality of learning (S9), validation of the coding scheme for content analysis (S1, S6), application of other SNA measures besides centrality and examination of multiple over lapping social networks (S7), exploration of the relationship between learning outcomes and centralities (S7) and, exploration of characteristics of lurkers or observers (S8). In general, findings of the selected studies are not generalizable as they are limited to the participants and the context they were conducted in therefore, to validate the findings, the studies need to be replicated in other contexts.

3.5 Discussion

There is plenty of stand-alone research using SNA, the CoP and the CoI frameworks in HEOL however, as we have found, there are a very limited number of studies that bring together constructs from SNA and these community-based frameworks. Therefore, this review provides a valuable synthesis of research that integrates SNA and the CoP and CoI frameworks in HEOL. There are three major themes that emerge from this systematic literature review.

Firstly, the review has revealed that for studies using SNA with the CoI framework findings are mixed in terms of the effectiveness of SNA to identify the different presences in a CoI. For instance, S1 reported no association between degree centrality and CP in a discussion forum whereas, S3 found a positive relation between the two constructs in a blogging community. Therefore, overall and in and out-degree centralities cannot reliably be correlated with a particular presence in a CoI, thereby necessitating complementing SNA with a qualitative analytical technique such content analysis as was done in the studies included in the review. Similarly, the one study (S2) integrating SNA with the CoP framework provides one example of the effectiveness of SNA in identifying the structural dynamics of the community and individuals within, however, a complete exploration of a CoP calls for combining SNA with qualitative analysis. Furthermore, the studies support the use of other statistical techniques like correlation and regression analysis, along with SNA and qualitative analysis, to determine significance of relationships between SNA constructs and components of a CoI and CoP. Clearly, at this point, as a stand-alone technique, SNA has not been shown to have the capacity to identify a CoI or CoP structurally, however, by isolating key sub-groups and participants, SNA does prove to be an effective filter for big data thereby reducing complexity of the data.

Secondly, we would like to bring to the forefront concerns about the untapped potential of SNA. None of the included studies consider how SNA can be used to identify a CoI or a CoP based on the overall structural characteristics of the underlying network. For instance, can we say that a highly-centralized network represents a CoP? Or is it a CoI? Considering that the frameworks are conceptually distinct, should we expect different network structures underlying each? If so, with regards to higher education, if we assume achievement in a course signifies learning, is there a direct correlation between learning within a CoP or CoI? Is there a qualitative difference in the way students learn within a CoP and CoI? Are there other SNA measures that might be more

appropriate for evaluating a CoI and CoP? Considering network visualizations, can a CoP and CoI be identified visually?

Thirdly, we would like to highlight the lack of consideration to students' attributes and performance in the selected studies. None of the studies consider student attributes and only two (S7, S10) examine how interactions translate into performance. In the context of higher education, if we accept that final grade is an indication of learning what can this tell us about students' learning in a CoP or CoI? Years of research shows that communities are effective in fostering deep learning but how can we explain a scenario in which if a student who appears as a well-connected node in the community does not perform as well as another student who is on the periphery? One explanation could be provided by examining student attributes like self-efficacy and goal orientation and their influence on participation and performance. Therefore, a holistic investigation of learning within communities warrants inclusion of attributional variables.

3.6 Conclusion

In view of the significance of community-based learning and its' relevance to HEOL, the motivation for conducting this review came from the heavy reliance on qualitative analysis in research involving the CoP and CoI frameworks which are increasingly being applied by researchers and practitioners of HEOL. The key objective of the review was to assess the efficacy of a quantitative technique, SNA, for evaluating and identifying a CoP and CoI based on structural components of each. The review reveals the dearth of research studies in HEOL that use SNA with the CoP and CoI frameworks thereby pointing to the inadequacy of research in the area. Our findings show that the small number and disparate results of the selected studies do not validate a correspondence between a specific SNA measure and a CoP or CoI structural component. However, repeated use of some SNA measures justifies further validation and therefore inclusion of these measures in future studies involving the CoP and CoI frameworks. Also, we believe that the potential of SNA to structurally evaluate and identify a CoP and CoI remains untapped as a limited number of SNA measures have been used and the power of network visualizations has not been considered. Considering the lack of literature found, the review highlights the need for further studies in HEOL that integrate SNA with the CoP and CoI frameworks and address aforementioned gaps in existing research. In terms of limitations, in line with our focus on pedagogical practices within a LMS, this review was limited to studies involving interactions within the LMS in the context of HEOL. Furthermore, the review was restricted to peer-reviewed

journal articles in English therefore, it does not consider investigations that might have been published in conference papers and book chapters, etc. or in other languages.

In conclusion, we recommend the development of a fully integrated methodological framework including SNA measures and structural components of the CoP and CoI frameworks. Not only would such a framework reduce reliance on extensive qualitative analysis, it would allow for an examination of the relationships between student attributes, participation, and learning. As such, the framework would present useful practical implication for practitioners, researchers and even students. Furthermore, by providing theoretical foundations to SNA measures, the framework would also address the concerns about the lack of theoretical grounding in research involving SNA (De Laat, 2014; Hamilton & Feenberg, 2005).

4. Chapter IV: Investigating Virtual Communities of Practice with Social Network Analysis: Guidelines from a Systematic Review of Research (Paper Two)

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Foreword

In the previous chapter, I presented the first of the two systematic literature reviews I conducted to develop a SNA based methodological framework for investigating and identifying CoPs and CoIs in HEOL, the IMF. Prior to the first review I did not expect that I would need to undertake another review however, while the first review gave me enough evidence to substantiate my conceptualization of the underlying structure of a CoI in terms of SP (discussed in Chapter 2, pp.45-47), I found only one study in HEOL that used SNA to investigate a CoP and that too not comprehensively. So, to validate my conceptualization of the structure of a CoP, I needed more literature on the structural components of CoPs and corresponding SNA constructs. For this, I decided to extend my search for studies to all contexts, not just HEOL and therefore, conducted another systematic review. After all, the characteristics of a CoP remain the same regardless of context. What I would need to adapt from the findings of this review would be the application and interpretation of the SNA constructs to CoPs in the context of HEOL. To remain consistent with the previous review, I used the same databases to conduct the searches and again, to ensure high quality of guidelines extracted, I restricted the searches to articles in peer-reviewed journals only.

4.1 Abstract

This paper presents a systematic review of research that uses social network analysis (SNA) to investigate virtual communities of practice (vCoPs). The review was driven by the lack of immediate value of time-consuming qualitative analyses typically conducted on vCoPs. The review seeks to assess the viability of SNA as a primary technique for structural investigation of vCoPs. Only 12 studies met the inclusion criteria for the review which evaluates and synthesizes the use of SNA for exploring vCoPs. Overall, the review reveals that the application of SNA has been context specific and restrictive, therefore, the SNA in each study is neither comparable nor comprehensive. However, detailed evaluation and consolidation of the SNA in the studies enabled the development of specific guidelines for investigating vCoPs with SNA. By allowing timely and reliable analytics on online data, the SNA based guidelines present valuable implications for ongoing analytics, design and facilitation of vCoPs.

4.2 Introduction

The communities of practice (CoP) framework is amongst the most widely cited influential social learning theories (Farnsworth, Kleanthous & Wenger-Trayner 2016). It has been applied extensively across various disciplines and contexts to examine processes such as knowledge management, information diffusion, formal and informal learning. Since the proliferation of synchronous and asynchronous online communication and collaboration tools such as emails, discussion forums, wikis, chats, web-conferencing, and social media (e.g. facebook, twitter, linkedin), there has been an increased interest in virtual CoPs (vCoPs) (Kirschner & Lai 2007). Research on vCoPs is conducted, among other sources, on online data obtained from the online platform or tool used. Such data can be obtained in real-time, is complete, and reliable therefore presents opportunities for ongoing analytics and intervention. However, much of the research on vCoPs has relied on mixed-methods including qualitative analyses of documents, interview data, and focus-group discussions along with online data (Johnson 2001; Lai, Pratt, Anderson & Stigter 2006; McLoughlin, Patel, O'Callaghan & Reeves 2018; Smith, Hayes & Shea 2017). Due to the time taken to conduct extensive qualitative analyses research using such methods is typically retrospective and therefore lacks immediate practical value in terms of monitoring and intervention. For such purposes, there is a need for more efficient, quantitative methods for investigating vCoPs.

Social network analysis (SNA) is a quantitative technique that examines relationships between individuals (and/or other entities) in a network. SNA distinguishes itself from other techniques as it is conducted on relational data and allows insightful visualizations of the data (Borgatti, Everett & Johnson 2003). Networks are formed when individuals interact albeit face-to-face or virtually. Communities are built on networks therefore networks underly all communities (Wenger 1998). Networks and communities represent different aspects of the same social configuration (Wenger, Trayner, & De Laat 2011). Networks provide the foundational structure through which information and resources travel to form communities. Based on the assumption that the unique participation dynamics (see section 2) within vCoPs would be reflected in the configuration of the underlying networks and ease of availability of online data from which networks of interactions can be generated, SNA presents as a suitable technique for a structural investigation of vCoPs. The questions then arise, it is possible to structurally identify and evaluate vCoPs with SNA? If so, how? Should this be possible, SNA could reduce or maybe even eradicate the need for extensive qualitative analyses previously required and support ongoing analytics and intervention in line with affordances (Gibson 1979) of online data.

Thus, the key objective of this review is to assess the viability of SNA as a primary technique for investigating vCoPs by surveying, evaluating and consolidating previous research in the area. To achieve this objective, the review is guided by the following research questions: What are the key characteristics of studies that use SNA for investigating vCoPs? Which SNA constructs have been used for the investigation of vCoPs? Which vCoP components have been explored with the SNA constructs and how? Can SNA be used as a primary technique for identifying and evaluating vCoPs? If so, how? The paper begins with an overview of the structural components of a CoP after which vCoPs are described. For details on the CoP framework readers are recommended to see references provided to Wenger's own publications. A brief introduction to SNA follows along with definitions of relevant SNA constructs. Then, the systematic literature is presented in sequence of the guiding research questions. Finally, in the conclusion guidelines for structural investigation of vCoPs with SNA are put forward with suggestions for further research and implications.

4.3 Structure of a Community of Practice

The CoP framework originated from the situated learning perspective (Brown & Duguid 1991; Lave & Wenger 1991) which postulates that individuals learn by interacting with others and the

environment within a CoP. The framework is multi-dimensional and has evolved over time however, participation of and interactions between community members remain the crux of a CoP. Even though a structural investigation alone of a CoP does not allow for a holistic evaluation, it can provide critical insights into the distinct community dynamics. Simply put, a CoP refers to a group of individuals with common interests (*domain*) who learn from each other within a *practice* that involves sharing of knowledge, experiences, and resources. Structural aspects of a CoP include the seminal idea of *legitimate peripheral participation* which lies at the core of the community. It is the cyclical process which signifies learning as new comers or novices join a community, acquire knowledge from experts, and gradually evolve into experts themselves (Lave & Wenger 1991). As individuals join and engage in a CoP, each develops a participation or *learning trajectory*. These trajectories are classified as: *full participation* (insider); *legitimate peripherality* (inbound trajectory to becoming a full participant or in a circular trajectory around the periphery); *marginality* (outbound trajectory and is either moving from being a full participant to becoming an outsider or is restricted to the periphery) and; *full non-participation* (outsider) (Wenger, 1998). The trajectory of an individual is determined by their level of *mutual engagement*, one of the key characteristics of a CoP. *Mutual engagement* refers to reciprocal interactions which are necessary for *negotiation of meaning* and knowledge construction (Wenger, 1998). Individuals can belong to more than one CoP at a time. These individuals are located on the *boundaries* of the CoPs and act as *brokers* of knowledge between the communities. It is at these boundaries that *practices* of CoPs overlap and innovation takes places as new perspectives are introduced and negotiated via mutual exchange (Wenger 1998). Mutual exchange is embedded within a web of social relationship, that is, the underlying network of interactions (Wenger, McDermott & Snyder 2002). The nature of interactions and activities within the community determine the orientation of the CoP. Orientations frequently overlap however the feel of the community is determinant by the dominant orientation (Wenger, White & Smith 2009).

4.4 Virtual Communities of Practice

Virtual CoPs (vCoPs) are technology facilitated CoPs where individuals interact virtually as opposed to face-to-face. vCoPs comprise of individuals that come together due to “shared practices, information, and knowledge that exists for them through mainly electronic means such as online forums, bulletin boards, and email” (Fang & Chiu 2010, p. 236). vCoPs are considered to be similar to face-to-face CoPs (Rheingold 1993; Thorpe at al. 2007; Wilson 2001) however,

"technologies extend and reframes how communities organize and express boundaries and relationships, which changes the dynamics of participation, peripherality, and legitimacy" (Wenger et al. 2009, p. 11). Virtual CoPs can form naturally and evolve organically as in the case of twitter-based community or can be planned and orchestrated, for instance, a closed facebook group based on a shared interest. In the organizational or educational context, vCoPs can be located within knowledge or learning management systems. Regardless of whether a CoP is face-to-face or virtual, the defining and unique structural characteristics of the community remain the same however, any kind of analytics needs to take account of the well-documented differences between face-to-face and vCoPs.

Virtual CoPs are not restricted by space or time. They are based on shared interest or an activity rather than enforced by shared location. Generally, the boundaries of vCoPs are more fluid unless restrictions have been out in place intentionally. vCoPs allow greater individual autonomy and more time for reflection as exchange is restricted to written text or other media and therefore not as spontaneous. vCoPs have greater diversity in members due to lack of geographical boundaries and therefore a bigger knowledge base. vCoPs typically take a longer time to develop and require facilitation or leadership and technological support (Gairin-Sallan, Rodriquez-Gomez & Armengol-Asparo 2010; Johnson 2001; Lai, Pratt, Anderson & Stigter 2006). In addition, research on face-to-face CoPs often relies on documents, interviews and survey-based data which is vulnerable to response rate and bias whereas research on vCoPs can be restricted to online data which is real-time, complete and reliable.

4.5 Social Network Analysis

SNA is a multidisciplinary technique rooted in concepts from graph theory, statistics, sociology, and anthropology. SNA is unique in that it examines relationships (e.g. friendship, kinship, co-worker, etc.) between human and/or non-human entities. Basically, SNA is conducted on networks comprising of entities represented by nodes connected via lines. Networks can comprise of one (e.g. individuals) or two (e.g. individuals, organizations) types of entities and are referred to as 1-mode or 2-mode respectively. The lines representing the relationship between nodes can be directed, identifying the sender or initiator and receiver. The lines can also be weighted, indicating the strength of the relationship. SNA encompasses numerous constructs and techniques of varying complexity that can be applied at the micro (individual) and macro (group) level. A key feature of SNA is that it allows insightful visual representation of interactional

data. Brief definitions of SNA constructs that will be discussed henceforth are provided below. These definitions have been obtained from Borgatti, Everett and Johnson (2013).

- *Density* is calculated by dividing the total number of ties in a network by the total number of possible ties.
- *Connectedness* is the proportion of pairs of nodes that are connected to each other by a path of any length.
- *Centralization* refers to the extent a network is dominated by a single node.
- *Degree centrality* is the number of connections of a node. In a directed network, the in-degree centrality is the incoming edges and the out-degree centrality represents outgoing edges.
- *Betweenness centrality* is the frequency with which a node falls along the shortest path between two other nodes.
- *Closeness centrality* is the sum of the length of the shortest path connecting a node to all other nodes.
- *Core-periphery* structure has core nodes and periphery nodes. The core nodes are connected to each other and the periphery nodes, but the periphery nodes are only connected to the core nodes and not to each other.
- *Coreness* is a continuous property of nodes. Two nodes that have high coreness will be connected to each other, and two nodes with low coreness will most likely not be connected to each other.
- *K-core* is a sub-group in which every node has a degree *k* or more with other nodes in the sub-group.
- *Clustering co-efficient* measures the extent to which a network has areas of high and low density.

4.6 The Systematic Review Process

4.6.1 Methodology

Fink (2014, p. 3) describes a systematic literature review as a "systematic, explicit and reproducible method for identifying, evaluating and synthesizing the existing body of completed and recorded work produced by researchers, scholars and practitioners". This review was conducted based on guidelines provided by Kitchenham (2004). As per the guidelines, firstly, the need for the review is identified. Secondly, the review protocol which includes the research

questions, database searches and study selection process is described. Finally, results of the review are presented.

4.6.2 Identifying Need for a Systematic Review

A search for previous reviews on vCoPs identified four literature reviews (Johnson 2001; Lai, Pratt, Anderson & Stigter, 2006; McLoughlin, Patel, O'Callaghan & Reeves 2018; Smith et al. 2017) none of which mention SNA. Literature reviews on the use of SNA in online learning environments (Cela, Sicilia & Sanchez 2015; Dado & Bodemer 2017) also make no mention of the CoP framework. Therefore, while there is plenty of stand-alone research on SNA and CoPs in the virtual context, a synthesis of research studies that integrate SNA with vCoPs has not been identified. Thus, this review promises to be a valuable addition to the literature.

4.6.3 Review Protocol

4.6.3.1 Defining the focus of the review

The key objective of this review is to assess the viability of SNA for structural investigation of vCoPs by surveying, evaluating and synthesizing previous research. Therefore, the review is guided by the following research questions:

RQ1: What are the key characteristics of research studies that use SNA to investigate vCoPs?

RQ2: Which SNA constructs have been used for the investigation of vCoPs?

RQ3: Which vCoP components have been explored with the SNA constructs and how?

RQ4: Can SNA be used as a primary technique for identifying and evaluating vCoPs? If so, how?

4.6.3.2 Database searches

Database searches for research studies were conducted in ERIC, SCOPUS, and EBSCOhost in July 2018. ERIC being the most used database for educational literature, SCOPUS one of the largest databases of peer-reviewed research, and EBSCOhost, inclusive of numerous databases spanning multiple disciplines were deemed appropriate choices for the review. Searches were conducted on the full text of articles for the terms *social network analysis* and *online* or *virtual community* or *communities of practice*. The search was limited to post 2000, journal articles in English.

4.6.3.3 Study selection

The selection process for studies is depicted in Figure 4. The database searches returned a total of 4,806 articles. Bogus and duplicate articles were removed leaving 3,669 articles. Assuming

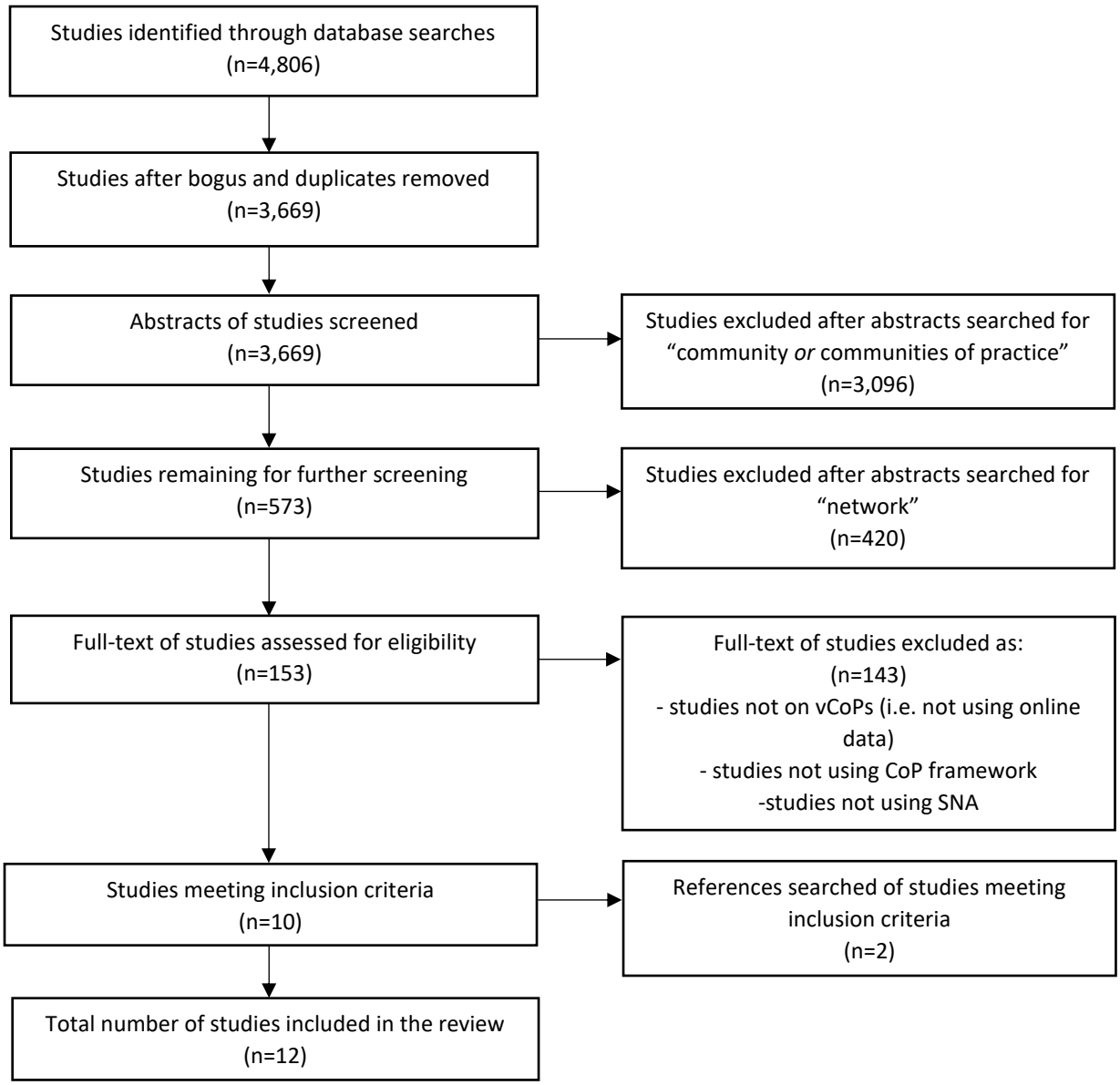

Figure 4. Study selection process

studies using the CoP framework and SNA would mention the terms in their abstract, the abstracts were first searched for the term community or communities of practice and then for the term network. Of the 3,699 articles, 573 abstracts mentioned CoP and of this subset 153 mentioned the term network. The 153 articles were then reviewed to identify studies on vCoPs

that use online data. This resulted in shortlisting of 29 studies. Upon further detailed review of the 29 studies, 10 were deemed relevant for inclusion in this review. Those studies that did not meet the inclusion criteria were either not using SNA and/or the CoP framework or where based on simulated data. A review of the references of the selected studies resulted in identification of 2 additional studies. Therefore, this review comprises of a total of 12 studies that use SNA for structural investigation of vCoPs. The paucity of research studies that actually ground analyses in the CoP framework as opposed to merely mentioning the framework is not surprising as has been reported by other reviews (e.g. Smith, Hayes & Shea 2017) as well.

4.6.3.4 Results of the review

The key objective of this review was to survey, evaluate and synthesize the use of SNA for investigation of vCoPs to assess the viability of SNA as a primary technique for identifying and evaluating vCoPs. Results of the review are presented in order of the guiding research questions.

4.6.3.4.1 RQ1: What are the key characteristics of studies that use SNA to explore vCoPs?

Table 7 summarizes the key characteristics of the selected studies listed in chronological order. Each study has been assigned a number which will be used to refer to the study henceforth. The last column in Table 7 shows whether the study assumed the existence of a CoP at the outset and then explored the community in light of the CoP framework (indicated by a ✓) or if the study sets out to determine the presence of vCoP (indicated by a ✗).

As shown in Table 1, the application of SNA to explore vCoPs has spanned multiple contexts. Of the 12 studies, 3 (S1, S5, S9) were conducted in the organizational context, 6 (S2, S3, S4, S7, S8, S10) in the context of healthcare, 2 (S6, S12) in the educational context and 1 (S11) was web-based. The studies include assessment of various online collaboration tools, each with different affordances (Gibson 1979). Majority, that is, 8 studies were on vCoPs within discussion forums. Other tools included, a knowledge management system, email, and social media (twitter). In the studies, the number of participants varied significantly ranging from a minimum of 43 to a maximum of 7,233 pointing to the scale of analysis possible using SNA. The studies can be

Table 7

Key characteristics of studies on vCoPs using SNA

No	Reference	Context	Tool	Participants	Duration	CoP
S1	Komorowski, Huu, & Deligiannis (2018)	Media professionals	Twitter	n=7,233 across 4 CoPs	-	✓
S2	Antonacci (2017)	Healthcare professionals	Discussion forum	n=1400 across 16 CoPs	7 years	✓
S3	Roland & Spurran (2017)	Medical education movement	Twitter	n=49,459	~ 2 years	×
S4	Siribaddana & Hewapathirana (2016)	Health information system	Phases 1 & 2: Discussion forum Phase 3: emails, mailing lists	Phase 1, n=21 Phase 2, n=46 Phase 3, n=27 Phase 4, n=11	1 year	×
S5	Lee, Kim, & Su (2014)	Steel manufacturer	Knowledge management system	n=8–238 members across 14-16 CoPs	-	✓
S6	Nistor et al. (2014)	Higher education	Discussion forum	n=133	~ 2 years	✓
S7	Xu, Chiu, Chen, & Mukherjee (2014)	Health knowledge sharing	Twitter	n=2,767	2 months	×
S8	Kimmerle et al. (2013)	Alternative medicine	Discussion forum	n=276	~ 3.5 years	×
S9	Kim, Hong, & Suh (2012)	Manufacturing company	Discussion forum	n=4,537 across 59 CoPs	4 months	✓
S10	Stewart & Abidi (2012)	Pain management healthcare	Discussion forum	n=46 across 7 hospitals	2 years	✓
S11	Murillo (2008)	News group (Usenet)	Discussion forum	n=2,842	1 year	×
S12	Thorpe et al. (2007)	School leaders	Discussion forum	n=43	17 days	×

grouped into those that set out to explore the formation of and identify a CoP (S3, S4, S7, S8, S11, S12) and those that assumed a pre-existing CoP (S1, S2, S5, S6, S9, S10).

Of the 6 studies conducted to explore and identify a CoP, only one (S4) constituted action research for assessing the impact of formal and informal training methods on the formation of a vCoP. The study was conducted in 4 phases, the last of which comprised of interview data which was not analysed with SNA. Data for phase 1 and 2 was obtained from discussion forums and

phase 3 data was extracted from emails and mailing lists. The other 5 studies in this group constituted ex post facto research in which data was extracted from the respective online tool or platform and analysed retrospectively. S3 and S7 examined the emergence of a twitter-based vCoP. S8 conducted an analysis of a web forum of followers of a community, S11 proposed and tested a methodology for detecting vCoPs from large web-based databases, and S12 explored participation in an online symposium in light of CoP features. The duration over which vCoP formation was evaluated varied from 17 days (S12) to approximately 3.5 years (S8). All studies, except S12 reported evidence of vCoP formation in the time span indicated. S12 acknowledged the lack of time for formation of a vCoP.

Of the studies that assumed a pre-existing CoP, the main objective was to explore the role of the online tool or platform in cultivating the vCoP. S1 examined the role of twitter in extending physical CoPs into the online space. S2 explored the growth of the vCoP over an extended period. S5 proposed and tested a tool for evaluating the structural health of vCoPs based on serious bottlenecks in knowledge-sharing activities among vCoP members. S6 investigated the extent to which technology acceptance impacts participation in a vCoP. S9 proposed and tested a diagnostic methodology for identifying different vCoP types based on activity within the community. S10 was conducted to explore communication patterns within a vCoP. In terms of duration, the time period over which the studies were conducted ranged from 4 months (S9) to 7 years (S2).

4.6.3.4.2 RQ2: Which SNA constructs have been used for the investigation of vCoPs? RQ3: Which components of vCoPs have been investigated and how?

Table 8 lists the SNA constructs, corresponding vCoP structural components and other methodologies used by the selected studies. vCoPs have been investigated using a mix of qualitative and quantitative techniques. Three (S5, S9, S10) of the studies were purely quantitative, using SNA supported by statistical analysis and/or log data analysis, while the remaining used SNA in combination with qualitative analysis including content, discourse, or topic analysis. The purely quantitative and mixed-methods studies have been grouped separately in the following sub-sections due to differences in the type of vCoP components explored and depth of analysis undertaken.

Table 8

SNA Constructs and Other Methodologies Used for Investigation of vCoPs

No	SNA Constructs	Corresponding vCoP Component	Other Methodologies
S1	Network diagram (layout parameters unspecified) Node size (unspecified parameter)	Visualization of community. Cross-community in interactions. Influential nodes	Statistical analysis Topic analysis Log data
S2	Betweenness centrality	Changes in centrality taken as indicators of LPP	Content analysis Statistical analysis
	Network centralization	Community growth	
	Network size Volume of posts	Participation	
S3	Network diagram (layout parameters unspecified) Node size (unspecified parameter)	Centralization, clusters, influential members, and intra-group interactions (vertical and horizontal)	Content Analysis Log data
S4	Density	Number of connections	Content analysis
	Degree centralities	Influence and prestige	
	Clustering coefficients	Closeness of participants	
	Radial network diagrams (based on degree centralities) Node size (based on out-degree)	Visualization of community	
S5	In and out degree centralities	Used for member and community classification (orientation)	Statistical analysis
	Network diagram (layout parameters unspecified) Node colour (based on sub-groups) Node shape (based on expertise)	Visualization of community.	
S6	Betweenness centrality	Expertise which influences participation. Participation and expertise used as indicators of core-periphery structure.	Discourses analysis Statistical analysis Log data
S7	In and out degree centralities	Prestige and power	Content analysis Statistical analysis
	Betweenness centrality	Control of information	
	K-core	Central members linked to expertise	
	Core-periphery structure Network centralization	Dominance	
	Sub-group degree centralities	Interactions across roles	
	Tie strength Reciprocity	Mutual exchange, collaboration	

S8	Betweenness centrality	Mediators (experts)	Content analysis Log data
	Temporal analysis using radial network diagram (node size and position based on betweenness centrality)	Process of LPP	
S9	In and out degree centralities	Member and community classification (orientation). Identification of core.	Statistical analysis
	Density	General connectedness and active knowledge exchange	
S10	Degree, betweenness and closeness centrality	Central and influential members	Statistical analysis Log data
	Core-periphery analysis	Members and threads that are at the centre of the networks	
	Coreness	Coreness used as another measure of centrality	
	Group-level centrality measures (degree, betweenness and closeness)	Across group dynamics	
	Radial network diagram (layout parameters unspecified) Node size (based on reads)	Visualization of community	
S11	Core-periphery structure	Mutual engagement	Content analysis Log data
	Size of network	Optimal size	
S12	Radial network diagram (based on degree centralities)	Central members Brokers/bridges	Discourse analysis

Quantitative studies.

S5, S9 and S10 used SNA with statistical analysis for structural evaluation of a vCoP. The three studies assumed a pre-existing vCoP and evaluated knowledge sharing within the community. S5 and S9 used directed and weighted networks representing number of posts and reads, where posting was considered as a knowledge creation event and reading was taken as a knowledge receiving or consuming activity. Therefore, lurkers (readers only) were accounted for, which is considered important from a knowledge sharing perspective. Since the networks were based on posts and reads, the studies did not evaluate mutual exchange. S10 used undirected networks in which a tie between two participants indicated that the participants had communicated on the same thread within a forum. The value of the tie was the number of threads communicated on.

The study analysed separate networks for posting and reading. Again, the emphasis was not on mutual exchange but rather on knowledge sharing and diffusion.

S5 used in and out-degree centralities to classify members as core, active knowledge creator (indicated by out-degree), active knowledge consumer (indicated by in-degree), and inactive. These classifications parallel Wenger's (1998) participation trajectories (see section 2). Therefore, degree centralities have been used effectively for categorization of participants. Furthermore, based on the proportion of the type of member, vCoPs were classified as knowledge-sharing, knowledge creation, knowledge consumption, and inactive. Again, a classification of the whole vCoP corresponds with Wenger et al.'s (2009) idea of community orientation. In terms of visual representation of the vCoP, S5 presented a network diagram of all vCoP members in which node colours differentiated sub-groups and node shape indicated expertise. However, the criteria for expertise was not specified, neither were the layout parameters for the diagram which was not discussed in detail.

In a similar vein, S9 proposed and tested a framework for identifying the knowledge sharing activity status in a vCoP. The framework again used degree centralities to classify members as balanced player, egoistic propagator, egoistic receiver, and knowledge isolator. Ratios of these classifications were then used for classification of vCoPs as active, learning community, active community, inactive community, and spreading community. A difference from the model presented by S5 was that based on the premise that the core of a community determines activities of the overall community, the ratios were only applied to the core. The core was calculated separately also using degree centralities of members. The cut-off for inclusion in the core was discretionary. S9 used network density as an indicator of general connectedness and mutual exchange within the community. Although S9 discussed betweenness centrality, the construct was not used in the analysis. The study did not present network diagrams for visualization of the vCoP.

S10 used a different approach than S5 and S9 by closely integrating SNA with log data analysis of number and time stamps on posting and reading. Time based analysis is effective in exploring rhythms of separation and togetherness in a vCoP however, SNA was not been used for this purpose. Within SNA, all three centrality measures (degree, betweenness, and closeness) and individual coreness for the posting network, and only degree centrality for the reading network

were used for the identification of active and influential members. Limiting the reading network to degree centrality makes sense as reading is considered as a knowledge acquisition activity only therefore, the other two centrality measures are not applicable. S10 identified lurkers as participants with a high degree centrality in the reading network. Posting degree centrality was used as an indicator of dominance, for example, a low posting degree centrality meant that a member was not contributing to all threads. Closeness centrality was taken as an indication of ease of reachability, and low betweenness centrality was taken to indicate that the network was not dependant on any single member in terms of information flow. The study also used core-periphery structure and group-level centrality measures (only for the posting network) to assess intra occupation and group interactions. Based on log data analysis on posts and reads, members of the CoP were classified as super users, active users, and inactive users. Again, this parallels S5 and S9, however, SNA was not used for this purpose even though degree centralities are indicative of the same classification, for instance, a member who was classified as inactive would have a posting degree centrality of zero. In terms of visualization of the community, S10 presented radial network diagrams in which node size was determined by the number of reads. The diagrams were not discussed beyond the representation.

Mixed-methods studies.

Majority, that is, 9 of the 12 studies used a combination of statistical and qualitative analysis, in addition to SNA. In each of these studies, SNA was used as a supporting rather than a key technique therefore its' application was limited. Certain SNA constructs were used repeatedly therefore, rather than discussing each study individually, findings are grouped as follows:

- *Network* – The nature of relationships in the network in the studies deferred based on the context and objective of investigation. The ties in the network of S1 represented interactions (following, liking, re-tweeting, and mentioning) within twitter accounts. In S2, a tie between nodes constituted a comment or response to a post. The twitter network in S3 comprised of retweets, favourites, and engagements. S4 generated networks from different online tools using different criterions. S7 used a network based on all conversations within twitter and a theme-specific network. S8 used undirected networks in which nodes were connected if they had posted to the same thread. The weight of the connection represented the number of common threads between the nodes. In S11, the network represented members posting to each other. S12 generated the network based on sequencing of the discussion thread as well as examination of the content of posts.

- *Individual centrality* - Individual level centrality constructs were used by majority of the studies. S2 used betweenness centrality to identify leaders in the community. S4 used degree centralities to measure participation. A high out-degree was associated with influence and in-degree with prestige. S6 used betweenness centrality to measure expert status. S7 used degree and betweenness centrality measures to identify central participants and roles which were equated with dominance and control of information flow respectively. S8 used betweenness centrality to measure the mediating position of a node. A high betweenness centrality was equated with experienced members who act as mediators and controllers of knowledge exchange.
- *Network centralization* – Network centralization was used by only three studies. S2 equated network centralization with CoP growth under the assumption that a centralized network indicates presence of experts. S7 took centralization as an indicator of dominance within the community. S8 made a reference to global centralization however, the construct was neither quantified nor discussed.
- *Core – periphery measures* - Four of the of studies examined the core-periphery structure of the vCop using different constructs. S6 assessed the core-periphery structure based on expertise and expert status which was determined by betweenness centralities. S7 used the K-core procedure (k=6) to identify dense clusters within the community and the core-periphery procedure to examine dominant members in the community. S11 used the core-periphery procedure as preliminary filter for a vCoP trait.
- *Temporal analysis* - Linked to the core-periphery structure analysis is the concept of legitimate peripheral participation (LPP) in a CoP which involves temporal analysis, that is, an examination of changes in the core and periphery structure over time. Only two studies analysed the LPP process within the vCoP. S2 used changes in betweenness centrality of members as an indication of LPP. S8 explored vCoP evolution by examining snap-shots of the underlying network at 5 intervals. The study used mean betweenness centrality in successive snap-shots of the network and positions of nodes in radial network diagrams (discussed below) to discuss the LPP process.
- *Other constructs* - A few other SNA constructs were used by a number of studies to assess overall connectedness and interactions within vCoPs. S4 used density and clustering coefficient as indicators of cohesiveness or closeness of members. S7 used the strength of ties as an indicator of interactions between different roles of members and the construct of

reciprocity as an indicator of mutual exchange indicating depth, continuity, and collaboration. S2 and S11 considered the size of the network as a marker of a CoP.

- *Community visualization* – The studies used different types of network diagrams for community visualization. Five (S1, S3, S4, S7, S10) of the studies depicted influential members based on node size. S1 and S3 did not specify criteria for node size, S4 based node size on out-degree, in S7 node size was indicative of betweenness centrality, and in S10 node size was based on posts read. S7 also used the colour of ties to represent different themes. Three of the studies (S1, S3 and S7) discussed local (within CoP or sub-groups) and global (external) interactions using network diagrams and S3 and S6 identified the core and centralization of the CoP visually. The layout parameters of the network diagrams in S1, S3, S4, S7 and S10 were not specified. Only 3 (S4, S8, S12) of the 12 studies used radial network diagrams to visualize vCoPs. A radial network diagram places nodes in a circular layout based on specified parameters. S4 did not state the parameters used for the radial diagram. S8 depicted a radial network diagram based on the betweenness centrality of nodes, that is, the more central nodes were placed in the centre and the least in the periphery with in-between nodes positioned accordingly. Similarly, S12 based the radial network diagrams on degree centrality of nodes and used the diagram to identify the facilitator, 2 key participants and another participant in a brokerage role. In terms of visualization of vCoPs, S8 and S12 make the most effective use of the power of SNA.

4.6.3.4.3 RQ4: Can SNA be used as a primary technique for identifying and evaluating vCoPs? If so, how?

This review was conducted with the objective of assessing the viability of SNA as a primary technique for investigating vCoPs. Overall, the review reveals that the application of SNA for investigation of vCoPs has been context specific and restricted to a select few SNA constructs and structural components of vCoPs. Therefore, it is evident that the potential of SNA for the aforementioned purpose has yet to be realized. Having said that, evaluation and consolidation of the SNA in each study has shed light on how this potential of SNA may be cultivated. To answer the overarching research question, the review concludes that SNA can be used as a primary technique for identification and evaluation of vCoPs. The rest of this section explains how.

Clearly SNA is applicable across various disciplines and contexts and can be conducted on networks of any size. The review highlights the importance of the relationships that are used to create the networks underlying vCoPs. Networks generated using different parameters are not

comparable therefore neither are the vCoPs they embody. For instance, the vCoP based on a posting and reading network such as that used by S5 is not comparable to the vCoP in S11 which is based on dialogue within a discussion forum. Furthermore, the relationship chosen depends on the objective of investigation. For instance, an educator who wants to assess student engagement in an online discussion forum should generate a network based on interactions (reciprocal posts) whereas, if the interest is in knowledge diffusion then a posts' read network would suffice. Moreover, the affordances of the online tool used need to be considered as they impact the configuration of interactions. For example, the twitter-based network in S7 is expected to be denser than the network in S5 which is obtained from a knowledge management system. Therefore, the structure of the vCoPs is not comparable. Thus, prior to the application and interpretation of SNA, the context of investigation, the type of relationship used to create the underlying network, and affordances of the online tool used need to be considered.

In terms of the structural investigation of vCoPs, the review shows that SNA allows for visual and quantitative identification and evaluation of a vCoP specifically the: joint enterprise; mutual exchange; participation trajectories, legitimate peripheral participation (LPP); local and global engagement, rhythms of participation and non-participation, core-periphery structure, experts and novices; insiders and outsiders; brokers or bridges; and community orientation.

It is found that *joint enterprise*, the process of mutual engagement which provides coherence to the community (Wenger 1998) has been assessed by SNA measures of cohesion such as density (S4 and S9). It is critical to note that, interpretation of the measure of density varies with the context as a dense network does not necessarily indicate *mutual exchange* which is a key feature of a CoP. *Mutual exchange* leads to *negotiation of meaning* and knowledge construction as individuals align themselves to *practices* of the community (Wenger, 1998). For an examination of mutual exchange, SNA measures such as reciprocity need to be used as is done in S7. The core-periphery structure is expected to be evident in the distribution of connections in the underlying network as the core should have a higher density than the periphery. None of the studies consider the distribution of density within vCoPs however, the measure of network centralization (S2 and S7) has been used for this purpose. Furthermore, in a vCoP, the core-periphery structure is not static as *novices* learn from the *experts* and replace them depicting *LPP* (Lave & Wenger 1991). The core-periphery structure of a CoP has been referenced to or discussed in all the studies with SNA measures such as K-core, core-periphery procedure and individual centralities and the

crucial process of *LPP* has been explored by 2 studies (S2 and S8). These studies conduct a temporal analysis of the vCoPs by examining the underlying networks at different points in time and tracking changes in the core-periphery positions of vCoP members. Therefore, a complete structural investigation of vCoPs calls for static as well as temporal analyses of the underlying networks. Note that for temporal analyses, the size of the network, that is, the number of nodes (individuals) needs to remain consistent.

In the studies, SNA constructs such as individual centralities (degree, betweenness, and closeness) have been effectively used to identify *insiders* and *outsiders* in vCoPs. Individual centralities have also been used to examine *participation trajectories*. However, the choice of centrality measure used varied with the objective of investigation and nature of relationships in the network. For instance, in a network based on dialogue, in and out-degree centralities were indicative of mutual exchange whereas, in a posting network in which nodes are connected only if they post to the same thread (e.g. S10), degree centrality represented the level of participation only but not mutual exchange. Therefore, interpretation of individual centrality measures is context specific. Thus, the measure chosen needs to be identified carefully. Individual centrality measures have also been used to assess rhythms of *participation and non-participation* in the community (Wenger, 1998) however, this can only be achieved by temporal analyses which tracks changes in centrality as was done in S8. *Brokers* or *bridges* within and across vCoPs have also been identified using the measure of betweenness centrality (S8 and S12). *Brokers* constitute a key feature of vCoPs by acting as conduits of knowledge between sub-groups within vCoPs (*local*) or multiple CoPs (*global*) (Wenger, 1998).

Two studies (S8 and S12) demonstrate the power of intuitive network visualization that allow for visual identification and evaluation of vCoPs. The studies use radial network diagrams based on individual centralities positioning core members towards the centre of the underlying network and others on the periphery. The radial network diagrams compliment the SNA constructs by depicting the distribution of members on the core to periphery spectrum, the spread of density, the positions of brokers and the groups they connect, and the overall orientation of the community as determined by the general configuration of connections in the underlying network.

Coming back to the question of the viability of SNA as a primary technique for investigating vCoPs, static and temporal analyses using a combination of appropriate SNA constructs and visualizations as discussed above appears to be a promising approach which warrants further research. Findings from this review have culminated into establishment of specific guidelines for structural investigation of vCoPs with SNA. These guidelines are provided on the following conclusion.

4.7 Conclusion

The guidelines for structurally investigating vCoPs with SNA are provided in table 9. These guidelines are at best a first step towards development of a methodological framework with SNA as a key methodology for identifying and evaluating vCoPs. The viability of SNA as an effective primary technique for investigating vCoPs remains contingent upon application and testing of the guidelines in case studies, a suggestion for further research. Considering that this systematic review was restricted to English journal articles in three databases, another suggestion for further research is to extend the scope of the review to other databases, conference papers, book chapters, etc. to develop the guidelines further by adding more SNA constructs and corresponding vCoP components or refining the guidelines presented.

Table 9

Guidelines for using SNA to Investigate vCoPs

SNA Constructs	**Corresponding vCoP Structural Components**
Network Cohesion (density, centralization)	Indicative of overall interactions and structure Changes in cohesion indicative of vCoP evolution Centralization indicative of core-periphery structure
Individual centralities (degree, betweenness, closeness) Core-periphery procedure K-core Coreness	Indicative of learning trajectories, legitimate peripheral participation, influential (core) members, and brokers
Reciprocity	Indicative of mutual exchange and negotiation of meaning
Radial network diagrams	Visualization of a vCoP. Layout based on individual centralities so that position of individuals represents distance from the core to periphery. All of the above components also identifiable in the diagrams.

Notes: The network, context of investigation and online tool used should be comparable.

In terms of implications, findings from the review led to the development of the guidelines in table 9. By using online data which can be obtained retrospectively or in real-time, SNA presents

the opportunity for ongoing analytics of vCoPs which is not possible by qualitative analyses. The guidelines can be useful for researchers interested in assessing such things as the impact of design and facilitation on the formation and evolution of vCoPs. The visual and quantitative indicators of vCoPs in table 18 are suggestive of the presence or lack thereof of a vCoP. It is important to note that SNA can by no means explore the non-structural components (e.g. conceptual and material artefacts) of vCoPs for which selected qualitative analysis would be required however, by acting as an initial filter, SNA can indicate the presence a vCoP. As stated earlier, researchers are encouraged to use and test the proposed guidelines and contribute towards the formalization of a methodological framework for identifying and evaluating vCoPs with SNA.

5. Chapter V: Social Network Analysis: A Framework for Identifying Communities in Higher Education Online Learning (Paper Three)

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Foreword

In the previous two chapters, I presented the two systematic literature reviews that I undertook to obtain guidelines for developing a SNA based framework for investigating and identifying CoPs and CoIs in HEOL. In this chapter I describe the framework I developed grounded in literature from the systematic reviews which corroborated my conceptualization of the structural components of CoPs and CoIs (discussed in Chapter 2). From the literature reviews I found that most of the CoP and CoI structural components discussed in Chapter 2 had been explored with corresponding SNA constructs in one study or another. However, none of the studies performed a holistic, structural investigation of CoPs and CoIs, let alone mention the need for such an understanding. I would like to reiterate here that the rational for development of the IMF came from an incomplete understanding of the structural aspects of CoPs and CoIs which I attributed perhaps to the lack of attention to quantitative methodologies. I would also like to recap and emphasize that an understanding of the structural underpinnings of CoPs and CoIs is a significant advancement in existing literature on learning communities in HEOL due to the pedagogical implications of the interactions within the communities as discussed in Chapter 2. Put another way, the assumption is that if students, lecturers, or tutors interact in ways that result in configurations of interactional networks that represent CoPs or CoIs, the benefits of learning within CoPs and CoIs could be implicated. Without this interpretation, the educational value of the SNA is lost in this case. I would also like to mention that this chapter presents the formalised version of the IMF including stages of application, interpretation and adaptation. When I initially developed the framework and tested it in the preliminary case-study

in this chapter and the detailed case-study in the following chapter, I had not yet finalized the sequence of the stages of application. The case-study in this chapter follows the formalised stages of application as I had the opportunity to edit this paper post formalisation of the framework. I would also like to point out that I was not involved in any way in the design and delivery of the course investigated in the case-study therefore, the data obtained is not susceptible to researcher bias and the analysis is completely replicable.

5.1 Abstract

This paper presents the Integrated Methodological Framework (IMF) which uses social network analysis (SNA) to structurally identify communities in higher education online learning (HEOL). Decades of research speaks for the value of community-based learning albeit in traditional, blended, or online environments. The communities of practice (CoP) and community of inquiry (CoI) are well-established, empirically tested frameworks that have been effectively used for exploration of community-based learning in professional and educational contexts. Typically, research using these frameworks has required extensive qualitative analysis making it tedious and time-consuming. Pivoting on structural similarities between networks and communities, the IMF embeds SNA constructs in structural components of the CoP and CoI frameworks. By structurally identifying a CoP and CoI, the IMF allows targeted, selective qualitative analysis thus reducing the extent of qualitative analysis required. Application of the IMF is demonstrated in a case study on an online blogging network. The study substantiates the IMF as an effective framework for structural identification of a CoP and CoI. The validity and robustness of the IMF is being further tested in ongoing research.

5.2 Introduction

Online learning[2] is growing at an exponential rate (Seaman, Allen, & Seaman, 2018) and is becoming increasingly sophisticated with continuing advancements in technology. Numerous learning design frameworks and models have emerged over the past couple of decades some of which are widely applied for designing complex online learning environments. However, despite the hype and interest in the field, there is limited research on the pedagogical impact of learning

[2] The terms "online learning" and "e-learning" include purely online and blended courses and have been used inter-changeably where necessary.

designs (Bower, 2017). Learning analytics, defined as the "measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (LAK, 2011, para.6), has relatively recently gained the attention of educational researchers due to accessibility to extensive data stored in learning management systems (LMS). Most commonly log data from LMSs is used to predict such things as student performance and retention (Lockyer, Heathcote, & Dawson, 2013). Social learning analytics which comprises of techniques for investigating social learning processes (Shum & Ferguson, 2012) is increasingly being used by educational researchers as well.

Social network analysis (SNA), a sub-category of social learning analytics, is a multi-disciplinary technique consisting of quantitative analytical methods based on unique theoretical constructs. It is conducted on networks of relationships between human and/or non-human entities (e.g. technology, documents and, organizations, etc.). The entities in a network are represented by nodes and the relationships by lines between the nodes. Networks can be one-mode (one type of entity) or two-mode (two different types of entities). Relationships within a network can be one or multiple and of any type (e.g. friendship, colleagues, or kinship). Networks can be directed (lines connecting nodes are arrows), identifying the initiator and receiver of a relationship, and/or weighted (thickness of line or arrow indicates strength of the relationship). SNAs' methodological distinctness lies in its emphasis on relational as opposed to attributional properties of data and the intuitive visual representations it affords (Wasserman & Faust, 1994). SNA comprises of numerous constructs which can applied at the whole network, sub-group and, individual levels. SNA has been used, among other things, for the investigation of pedagogical dynamics of group structures and communities in e-learning (Cela, Sicilian, & Sanchez, 2015), however, the lack of appropriate pedagogical grounding has made findings vulnerable to interpretations (De Laat, 2014; Shea et al., 2013).

Networks form in any learning environment albeit face-to-face, blended or purely online, as individuals and resources interact in the virtual and/or physical space. In this paper, our analysis and discussion is restricted to one-mode networks comprising of individuals and their interactions within a LMS only. Connections in a network in and of themselves do not signify learning but represent the potential to learn by laying out channels through which information and resources can travel to create knowledge. A network does, however, form the foundation of the pedagogically significant construct of a community of learning. All communities are networks,

however not all networks are communities and the educational affordances of the two differ (Wenger, Trayner, & De Laat, 2011). A network is defined as, "a set of connections among people…" used for solving problems, sharing knowledge, and making more connections (Wenger et al., 2011, p.9). Alternatively, a community is, "a group of individuals identifiable by who they are in terms of how they relate to each other, their common activities and ways of thinking, and their beliefs and values" (Biza, Jaworski, & Hemmi, 2014, p.162). The importance of learning in a community is a widely-held belief resting on decades of research (Zhao & Kuh, 2004). Communities are considered as essential for knowledge generation which is an integral component of the learning process (Garrison & Anderson, 2003). Learning in various forms of community has been described as "necessary for creating and confirming meaning and…essential for achieving effective critical thinking" (Swan, Garrison, & Richardson, 2009, p.4).

In a learning environment, the formation of networks is inevitable. The pedagogical effectiveness of community-based learning and structural parallels between networks and communities make SNA the natural choice of methodology for exploring communities of learning in the online space. In this methodological paper, we present a theoretically informed Integrated Methodological Framework (IMF) for structurally identifying communities of learning in higher education online learning (HEOL). The IMF grounds SNA in structural components of empirically tested and well-established community-based learning frameworks, namely, the communities of practice (CoP) (Wenger & Lave, 1991) and community of inquiry (CoI) (Garrison, Anderson, & Archer, 2000). The IMF includes macro and micro level SNA constructs corresponding to overall network structure and individual nodes. We begin by presenting the rationale for development of the IMF followed by a synopsis of the structural components of the CoP and CoI frameworks. We then present and describe the IMF in detail. Finally, we demonstrate use of the IMF in a case study on an online blogging network.

5.3 Rationale for Development of the Integrated Methodological Framework (IMF)

Motivated by the lack of quantitative research using the CoP and CoI frameworks commonly applied to research in online learning (Shea & Bidjerano, 2010; Smith, Hayes, & Shea, 2017), an interest in SNA, and the relationship between networks and communities, we recently conducted a systematic literature review of research studies that integrate SNA with the CoP and CoI

frameworks (Jan, Vlachopoulos, & Parsell, 2019 [Chapter 3][3]). The handful of studies (9 using the CoI and 1 using the CoP framework) that met the inclusion criteria were reviewed to specifically: identify the SNA constructs used; examine complementary analytical techniques employed with SNA; assess the effectiveness of SNA as technique for structurally exploring a CoP and CoI and; synthesize limitations of existing research. The dearth of studies found, disparate outcomes of existing studies and, use of limited SNA constructs, pointed to the infancy of research in the area especially, the untapped potential of SNA to effectively explore macro and micro level dynamics of learning communities. For instance, results of studies using SNA and the CoI framework varied depending on the context of the study, e.g. in a study (Shea & Bidjerano, 2010) on a discussion forum, no relationship was found between centrality (see section 5.5.4.3) and cognitive presence (CP) (see section 5.4.2), whereas another study (Jimoyiannis, Tsiotakis, & Roussinos, 2012) on a blogging network reported a positive association between centrality and CP. The review did, however, validate the capacity of SNA to identify key groups and participants within large networks, the qualitative analysis of whose interactions would be indicative of dominant components of a CoP and CoI thereby greatly reducing the need for extensive qualitative analysis of all interactional data. Most importantly, the review highlighted key gaps in existing research, that is: to date no research has considered how SNA can be used to identify a CoP or a CoI based on the overall structural characteristics of a network; there has been no examination of the relationship between learning and participation in a community, assuming performance in a course of study indicates learning; there has been no investigation on the impact of community structure on the nature and quality of interactions and; a narrow range of SNA constructs have been used repeatedly prompting the notion that there might be other constructs that correspond more appropriately with certain components of a CoP and CoI. These critical conclusions from the review guided us and acted as key drivers for development of the IMF. Before presenting the IMF, we outline its' theoretical underpinnings which comprise of certain components of a CoP and CoI. The aim here is to establish the structural link between SNA and the CoP and CoI frameworks.

5.4 Theoretical Underpinnings of the IMF

Dating as far back as early 1900s, the concept of learning communities has undergone significant evolution (Fink & Inkelas, 2015). The flexibility to communicate and collaborate irrespective of

[3] The second systematic review (Jan, 2019) is not mentioned here as it was written after publication of this paper.

time and space provided by technology has redefined community-based learning leading to the emergence of various models of learning comprising of different types of communities, for instance, learning communities, knowledge-based communities and, personal learning networks. The CoP and CoI are two popular, well-tested, community-based pedagogical frameworks that have been commonly applied to online learning (Conole, 2011). While both frameworks are driven by the social dimension of learning, learning and teaching dynamics within each are unique, leading to different structural representations of the underlying networks which therefore allow for distinct interpretation of SNA constructs.

5.4.1 Communities of practice

Despite successive revisions since the introduction of the theory of situated learning (Lave & Wenger, 1991), the essence of the CoP framework remains the same to date. A CoP represents a group of individuals whose shared interests bring them together in a network of relationships to form a practice characterized by mutual engagement and a shared repertoire of resources (Wenger, McDermott, & Snyder, 2002). Mutual engagement refers to interactions between individuals which occur within a network and lead to rhythms of participation and non-participation (Wenger, White, & Smith, 2009). The process of legitimate peripheral participation or identity development (Lave & Wenger, 1991) signifies learning as newcomers evolve into experts and progressively move from the periphery to the centre of the community. These progressions or learning trajectories are classified as: full participation (insider); legitimate peripherality (inbound trajectory to becoming a full participant or in a circular trajectory around the periphery); marginality (outbound trajectory and is either moving from being a full participant to becoming an outsider or is restricted to the periphery) and; full non-participation (outsider) (Wenger, 1998). Structural changes in a network over time would depict these learning trajectories which signify legitimate peripheral participation, identity formation and, learning – the critical components of a CoP. The CoP framework is rooted in the notion of professional learning, specifically, the apprenticeship model, and has been applied in the professional learning and knowledge management context extensively (Cross, Laseter, Parker, & Velasquez, 2006). The framework extends to the educational context and is being increasingly applied as such.

5.4.2 Community of inquiry

Grounded in Dewey's (1859-1932) ideas on critical thinking, collaborative learning and, practical inquiry, the CoI framework was specifically developed as a guide for online pedagogical practices and research (Garrison, 2017). It is one of the most widely cited and used frameworks and has empirically proven to be effective in explaining individual and collective learning in traditional and e-learning contexts (Shea & Bidjerano, 2010). The CoI framework is a learning centred, process model driven by the intricate dynamics between different stages of three intersecting presences: social presence (SP); teaching presence (TP) and; cognitive presence (CP). Garrison, Anderson, and Archer (2000) define SP as "the ability of participants in a community of inquiry to project themselves socially and emotionally as 'real' people…" (p.94) and CP as "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse" (p.89). TP is described as a presence that "manages the environment and focuses and facilitates learning experiences" (Garrison & Kanuka, 2004, p.98). Ample research has been conducted on each of the presences independently however, the dynamic inter-relationships between SP, TP and, CP over a course of study have not been the subject of much investigation (Garrison, 2017). Group cohesion or degree of interactions between participants is a component of SP which is always present in a CoI (Garrison, 2017). Therefore, it can be reasonably assumed that the overall density of a network signifies the level of SP in a CoI. This assumption has also been validated by recent studies (Shea & Bidjerano, 2010; Tirado, Hernando, & Aguaded, 2015). SP is an integral precursor to collaboration and critical discourse (CP) and supports and sustains the community once it has been established with a common purpose and academic identity, a function of TP (Garrison, 2017). As such, SP can be viewed as the foundation of a CoI supporting CP, also described as the interplay between the public (social and communal) and private (individual) worlds and TP, referred to as an act of doing, embodied by lecturers, tutors, and students alike (Garrison, 2017). As a course of study develops, high levels of SP are replaced by TP and CP as participants assume different roles and responsibilities. SP acts as a mediator between CP and TP which becomes more distributed as SP and CP develop (Garrison, 2017). As a starting point, taking the degree of interactions as representative of SP, knowledge of the learning design coupled with selective qualitative analysis, would make it possible to ascertain structural dynamics between SP, TP and CP and their respective influence on learning based on properties of the overall network and individual nodes.

5.5 The Integrated Methodological Framework

Having explained the theoretical grounding for the framework, we now present the Integrated Methodological Framework (IMF) for identifying a CoP and a CoI in HEOL based on the structural characteristics of underlying networks. The IMF comprises of a visual illustration of the key concepts underlying the framework as well as four sequential components. It is important to note that Figure 5 as a stand-alone does not provide sufficient information for using the IMF however, we believe the visual is necessary for a conceptual understanding of the framework.

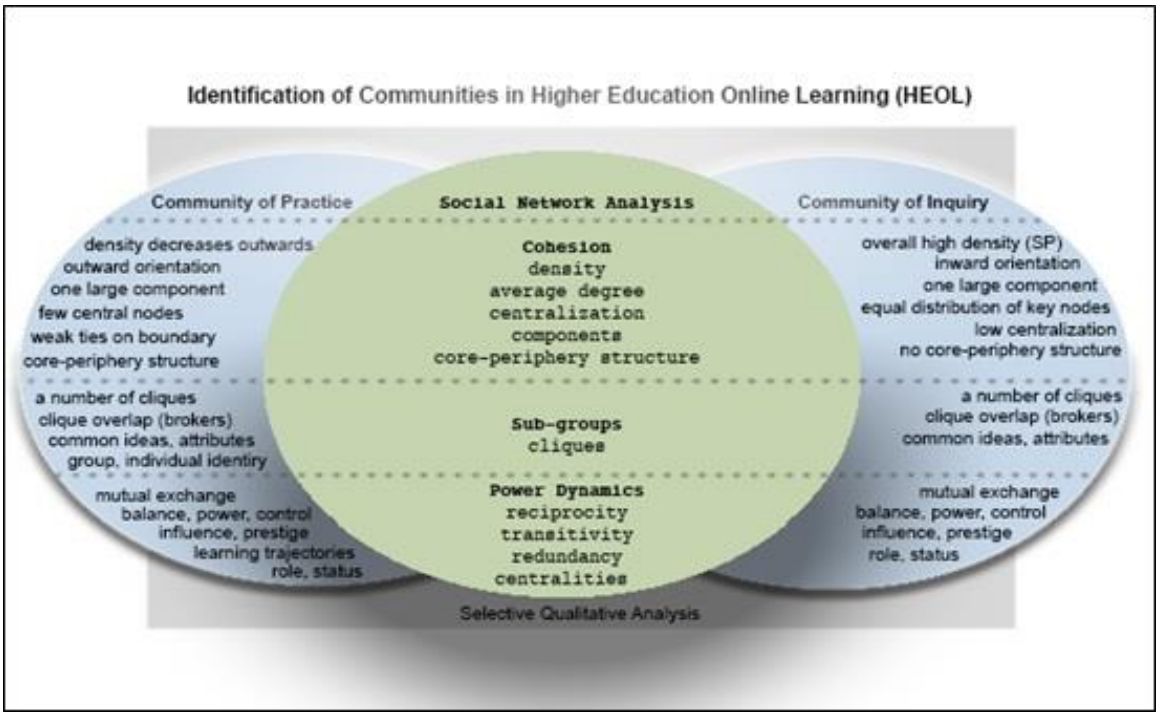


Figure 5. Integrated Methodological Framework

Figure 5 captures the essence of the IMF. That is, being the key methodology driving the framework, SNA is placed in front with corresponding structural components or identifiers of a CoP and CoI positioned behind the SNA constructs on the left and right side respectively. The identifiers in the CoP and CoI columns indicate the SNA constructs expected in each community (explained in detail in section 5.5.4). The dotted lines in Figure 5 represent the three different levels of analyses allowed by the IMF, i.e. whole-network, sub-group, and individual level. Selective qualitative analysis is positioned in the background to depict the support it provides to the SNA, if required.

Figure 6 shows the four sequential components of the IMF. Each component precedes the other in the application and interpretation of the framework and is described in detail in the sections indicated in the figure.

Figure 6. Components of the Integrated Methodological Framework

5.5.1 Social Network Analysis (SNA) Parameters

SNA is applicable in any context involving relational data however, before using the technique, it is necessary to establish certain SNA parameters specific to the context of investigation and address some commonly known challenges with using SNA within the specific context. In the IMF:

- The networks are one-mode in which the nodes represent lecturers, tutors and/or students in a course of study.
- The relationships between the nodes comprise of online, text-based interactions, i.e. each interaction is considered as one connection or tie.
- The size of the network is determined by the number of nodes, i.e. students, lecturers, and tutors.
- The network is closed, structured and, restricted to the interactions within the LMS during an activity, therefore, the boundaries of the network are well defined (Laumann, Marsden, & Prensky, 1983).
- Data from the LMS used to create the networks is factual, real-time, and reliable therefore the networks represent valid relationships (Wasserman & Faust, 1994).
- The issue of incomplete or missing data (Borgatti & Molina, 2003) only arises in two situations: in the case of a longitudinal study in which some students withdraw or join a course later (Grunspan, Wiggins, & Goodreau, 2014) or: in the case of non-consent of participants represented by nodes. These situations become problematic if the missing node is a bridge

(connector) between two sub-groups etc. (Borgatti & Molina, 2003). Conclusions drawn from networks with missing data need to acknowledge this issue.

- An ethical conflict between subject protection and data set completion (Grunspan et al., 2014) exists as non-participants who have ties with participants are included in the network diagrams. Therefore, in the absence of consent, an in-depth analysis of data associated with non-participants cannot be undertaken – a limitation of SNA.
- LMS data allows for obtaining snap-shots of a network at different points during a learning activity therefore, by comparing successive snap-shots (or time slices) of the network, dynamic social relationships can be examined (Emirbayer, 1997).

For further information on SNA we refer interested readers to Borgatti, Everett, & Johnson (2013).

5.5.2 Stages of Application

Networks and communities are dynamic structures continuously evolving with changing levels of engagement of participants. A network forms as soon as two individuals interact however, a community takes time to form (Wenger, 1998). Therefore, identification of a community requires static and temporal exploration of the underlying network as it gradually evolves into a CoP or CoI, if at all. Correspondingly, application of the IMF is a multi-stage process whereby each stage determines the actions to be taken in the next. Before going further, it is important to clarify some key terms used henceforth. A *static* network represents a snap-shot of all interactions between nodes in a network at a certain point in time. We refer to a static network as the *cross-section* of a network or the *cross-sectional network* (the terms are used inter-changeably). For instance, in a discussion forum spanning 10 weeks, interactional data extracted at the end of week 1 would be the cross-section of the network at the end of week 1. A *temporal* analysis involves comparing the structural changes (caused by changing relationships or interactions) in successive cross-sections of a network. Hence, the cross-sections represent time-slices of the network. We now describe each stage of application of the IMF in detail.

- **Stage 1 – Preparation of data:** Firstly, extract cross-sectional interactional data from the LMS and code into matrices for conducting SNA in software like UCINET (Borgatti, Everett, & Freeman, 2002). The time at which a cross-sectional network is extracted will vary with the context of investigation. For instance, the design of a learning activity could be such

that we need to examine a cross-sectional network after 5 weeks of activity (the cross-section would comprise of cumulative interactions over 5-weeks) as opposed to after 1 week. To create matrices, place participants in rows and columns as shown in Table 10. A value of >0 between two participants indicates a connection or tie and a value of 0 indicates otherwise. The matrix should be weighted indicating the strength of the relationship, that is, the number of times two participants interact (e.g. nodes A and B interact 5 times in total as shown in Table 10), and directed, that is, the initiator and receiver of the interaction is identified (e.g. A initiates interaction with B two of the five times).

Table 10. Matrix of interactions between 5 nodes

	A	**B**	**C**	**D**	**E**
A	0	3	0	2	0
B	2	0	0	1	0
C	0	1	0	0	1
D	0	0	1	0	1
E	1	0	3	0	0

Secondly, generate radial network diagrams based on degree-centralities of nodes and weight of edges in software such as Social Network Visualizer (Socnetv, 2017). The matrices created in UCINET can easily imported into Socnetv. The radial diagrams place a participant with the highest number of connections and least distance from others towards the centre of the network. Thirdly, corresponding with the network diagrams, calculate relevant SNA constructs in UCINET. At a minimum, the number of ties, average degree or density, centralization index, number of components, number of nodes in largest component, number of cliques, core nodes, reciprocity and, transitivity should be calculated. Other constructs can be added depending on the research objective and level of analyses required. The SNA constructs and network diagrams can be examined in either order or simultaneously.

- **Stage 2 – Static and temporal analysis:** Examine and interpret the SNA constructs and/or diagrams obtained in stage 1 and arrive at a preliminary conclusion regarding the type of community formed, if any (static analysis). Then, guided by the preliminary conclusion, conduct a temporal analysis by comparing successive cross-sectional networks for structural changes, for instance, a changing core-periphery structure, changes in the

number of cliques, etc. Such a comparison is necessary to validate preliminary conclusions made from the static analysis. For instance, if a CoP is suspected, a changing core-periphery structure of successive cross-sections signifies the process of legitimate peripheral participation without which we cannot claim the presence of CoP. Changes in reciprocity, transitivity, and sub- group structures in successive cross-sections are indicative of shifting dynamics, roles and statuses, individual and whole-network trajectories, etc. (explained in section 4.4). As another example, if a CoI is observed in a couple of successive cross-sections but does not sustain in the following cross-section, we cannot claim that the learning activity leads to the formation of a CoI. For that we need to look at the overall aggregate (cumulative) network which takes us to the next stage.

- **Stage 3 - Aggregate analysis:** Examine cumulative interactions over the entire duration of a learning activity. This examination would include an aggregated network diagram and the SNA constructs listed in stage 2. Although the aggregated network does not reveal temporal community dynamics, the overall structure of the network indicates the type of community formed over the entire course of an activity.

- **Stage 4 - Qualitative analysis:** Having identified the type of community formed, should there be a requirement to conduct qualitative analysis, content of interactional data from key participants (identified by their positions in the network diagrams) can be extracted from the LMS. For instance, in a CoP, if a researcher wants to identify the type of posts that attract others, he/she would look at posts of core participants to identify patterns. In a CoI, assuming density represents SP which underlies TP and SP, qualitative analyses could be conducted on dense pockets to assess the presence of CP and TP. Here it is important to note that the IMF identifies a CoP and CoI based on structural characteristics of the frameworks only. Once the type of community has been identified, further detailed analyses including qualitative analysis would be required to confirm the presence of a CoP and/or CoI based on other components of the frameworks. What the IMF does is allow the preliminary identification of the community and reduces the amount of analysis required as selective qualitative analysis can be conducted.

5.5.3 Adaptation to Context

One important aspect in technology-mediated communities of learning is the role of technology (tools) used to facilitate the process (Wenger, White, & Smith, 2009). Apart from social media

Table 11. Adaptation of the IMF to Context

Tool	Discussion forums	Blogs	Wikis
Key features (University of Adelaide, 2017)	• Topic centred • Can be started by anyone on topic of choice • Equality of all participants • Responses are required for discussion to occur • Interested users can follow any topic of interest	• Author centred • Posts made by the author only • Author has dominant presence • Comments made on original post • Presented in reverse chronological order	• Content centred • Posts made by a group • Development of final post is documented showing individual participation • Collaborative activity aimed at reaching consensus • Focused on content developed rather than individual participants • Comments not included in the content
Nature of interactions	• High degree of interactions • Chains of nested comments • High level of exchange (reciprocity)	• Lower degree of interactions • Comments not deeply nested • Lower level of exchange (reciprocity)	• Edits to content represent interactions rather than comments • Interactions limited within group • Exchange limited to comments within group
Example of interpretation	A student with a number of incoming ties could be involved in an in-depth exchange with a selected few others on a specific topic. Therefore, the student might be a prestigious participant within that particular thread only and not necessarily in the overall discussion forum.	A student with a number of incoming ties clearly attracts others to engage with the students' post and therefore holds a prestigious position. If the same student has a number of outgoing ties as well, the student is actively reading and commenting on other posts is therefore influential.	A student with high connectivity is a key contributor to the content and holds an influential position.

(facebook, twitter, etc), there are three dominant tools within a LMS that are used for learning purposes: discussion forums; blogs and; wikis. While each of these tools involves asynchronous interactions, each is used for a different purpose which governs the nature of interactions that occur within each. Therefore, we would expect to see different configurations of the relational networks derived from each tool. Thus, the networks derived from discussion forums, blog and wikis are not comparable to one another. The IMF needs to be adapted and interpreted considering the affordances of the tool used to foster the creation of communities of learning. Table 11 shows the key differences between discussion forums, blogs and, wikis along with the nature of interactions expected within each tool and an example interpretation for each.

5.5.4 Interpretation

Certain SNA constructs have been selected for inclusion in the IMF based on their correspondence with parallel structural components of a CoP and CoI and findings from our literature review (Jan, Vlachopoulos, & Parsell, 2019 [Chapter 3]; Jan, 2019 [Chapter 4][4]) discussed in section 5.3. The SNA constructs have been grouped at the whole-network (cohesion), sub-group (cliques), and individual level (power dynamics). Preliminary identification of a CoP and CoI hinges on measures of network cohesion only. Clique analysis and power dynamics are applied subsequently and interpreted according to the community identified by the measures of cohesion. The following sections describe the SNA constructs and explain interpretations in terms of corresponding a CoP and CoI components.

5.5.4.1 Cohesion

Measures of network cohesion are used for preliminary identification of a CoP and CoI. The *density* of a network is the total number of ties divided by the total number of possible ties. Densities are almost always lower in smaller networks therefore, for comparability, the preference is to use the average degree. The *average degree* is the average number of connections each node has in the network. *Centralization* refers to the degree to which a

Table 12. Identifiers of a CoP and CoI Based on Network Cohesion

SNA Construct	CoP	CoI
Density / Average degree	Density of the network decreases from the centre outwards. A few nodes with strong ties (insiders) positioned towards the centre of the network with a number of nodes with weak ties on inbound or outbound trajectories on the periphery. A few isolates (outsiders) that never join the community.	Overall dense network indicative of SP with relatively equal distribution of ties and key nodes across the network.
Components	One large component.	One large component.
Network centralization	High network centralization.	Low network centralization.
Core-periphery structure	A clear core-periphery structure representing legitimate peripheral participation.	No core-periphery structure representing equal participation.

[4] The published paper does not include a reference to the second systematic review (Jan, 2018) as it was written after this paper was published.

network is focused on one or a few nodes. The higher the density or average degree and centralization, the greater the cohesion. A highly centralized network is controlled by a few powerful nodes and is therefore restrictive (Carolan, 2014). A *component* is a group of nodes in which at least one path connects all nodes. The bigger the main component, the higher the overall cohesion. The *core-periphery structure* of a network identifies nodes that belong to the core and periphery of a network thereby indicating central, influential nodes (Borgatti et al., 2013). Table 12 shows identifiers of a CoP and CoI based on measures of network cohesion.

5.5.4.2 Sub-groups

Once a community has been identified as a CoP or CoI based on measures of cohesion, sub-group analysis is used accordingly for further investigation. *Cliques* are groups of nodes in which every node is connected to every other node. Cliques represent solidarity, shared norms, trust, identity and, collective behaviour. A comparison of attributes and behaviours of nodes belonging to a clique with nodes in other cliques can provide useful implications for learning depending on the context of analysis (Carolan, 2014). Overlapping cliques occur if a node belongs to more than one clique. While we would expect multiple, over lapping cliques in both communities, implications of clique membership differ in a CoP and CoI. Once dominant cliques and nodes in them have been identified, qualitative analysis would be required to isolate components of a CoP and CoI as illustrated by the examples in Table 13.

Table 13. Interpretation of Sub-Group Analysis Based on CoP and CoI Components

SNA Construct	CoP	CoI
Cliques	A number of overlapping cliques. Overlapping nodes represent brokers/bridges. e.g. selective qualitative analysis of contributions by brokers/bridges would assess significance of the contributions towards material and/or conceptual artefacts for shared repertoire of the community.	A number of overlapping cliques. Overlapping nodes represent brokers/bridges. e.g. selective qualitative analysis would identify a dominant presence in a specific clique or in brokers/bridges thereby establishing their role in the community.

5.5.4.3 Power dynamics

We view power dynamics in terms of the stability of and control within a network. To assess power dynamics we use measures of reciprocity, transitivity, redundancy, and degree centrality (see Table 14). The *reciprocity* of a network is the extent to which ties are bi-directional or

symmetrical between nodes and shows the direction of information flow. It indicates the network's stability as reciprocated ties tend to be more stable over time. *Redundancy* is the existence of alternate paths between nodes. A t*ransitive* triad occurs when A -> B, B -> C and A -> C. A network with high transitivity appears clumpy with long distances. The higher the transitivity and redundancy of a network, the lower the power and control (Borgatti et al., 2013). Note that the CoP framework does not discuss issues of power and control that are critical determinants of flow of information and resources (Hughes, Jewsen, & Unwin, 2007). Examining the reciprocity and transitivity of a network reveals power dynamics within a CoP and CoI in terms of the role and status of participants. C*entrality* measures provide information regarding individual influence and prestige. *Degree centrality* is the number of connections of a node. *In-degree centrality* is the number of incoming ties and *out-degree centrality* the number of out-going ties (Borgatti et al., 2013). A high out-degree has been linked to influence whereas a high in-degree signifies prestige (Hanneman & Riddle, 2005). An influential node spreads information by reaching out to other nodes whereas, a prestigious node attracts interaction from other nodes. Tracking the level of influence and prestige of a node is indicative of the function or role of a node in a network (Rissen, 2014). While the selected SNA constructs provide a good indication of the power dynamics within a community, again a detailed investigation would require the support of selective qualitative analysis.

Table 14. Interpretation of Individual Power Dynamics within a CoP and CoI

SNA Construct	CoP	CoI
Reciprocity	High reciprocity indicative of mutual exchange and negotiation of meaning. Lower reciprocity compared to CoI signifying a more hierarchical network in which power resides with key participants.	High reciprocity indicative of mutual exchange and potentially integration and resolution phases of CP. Higher reciprocity compared to CoP signifying an equal distribution of power.
Transitivity / Redundancy	Lower transitivity and redundancy indicative of a community controlled by experts (in the core).	Higher transitivity and redundancy indicative of non-restrictive community in which information flows freely.
Centralities	Degree centralities of individuals indicative of individual trajectories. In-degree and out-degree indicative of level of expertise.	Individual degree centralities indicative of high SP and potentially CP and TP. In case of a node being a tutor/facilitator, degree centrality represents TP as well.

5.6 Case Study: Evolution of an Online Blogging Community

To illustrate use of the IMF, we present a case study on an online blogging activity, within the LMS, used to create a sense of community amongst first-year students in a human sciences

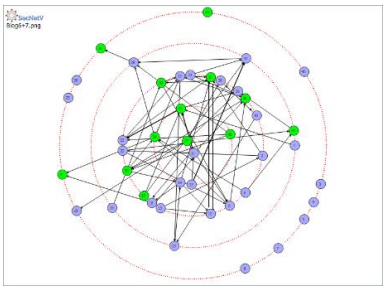
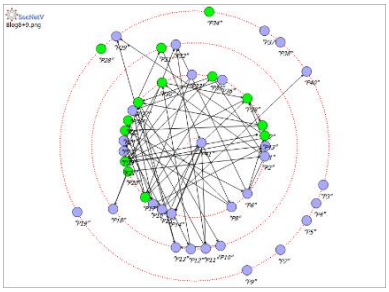
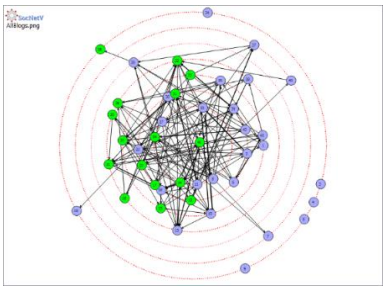
course at a large metropolitan university in Australia. The course ran in semester 1 of 2017 for a total of 13-weeks and included weekly online blogs for 10 weeks (5 non-interactive blogs and 5 interactive blogs). The interactive blogs required students to make a blog post and comment on each other's post within the week. The course was primarily online with 2 optional on-campus days in the 3rd and 9th weeks of the semester. The course included 1 lecturer, 2 tutors and 43 students in all. Fifty percent of the grade was allocated to the e-portfolio and online tasks which included quizzes, two reflections and, the weekly blogs. In line with the key objective of the lecturer to assess the learning process rather than the product, the e-portfolio and online activities including the blogs weighed significantly on the final grade. We used the IMF to examine evolution of the relational network over the 5-week period of interactive blogging. The blogging activity did not include the lecturer and tutors therefore the network consisted of 43 nodes (students only). We demonstrate the effectiveness of the IMF in identifying the type of community formed, if any, based on overall network structure and properties of cross-sectional and cumulative networks.

Sage 1 – Preparation of data: Interaction data was extracted from the LMS (Moodle) at the end of weeks 1 & 2 and 3 & 4 to obtain cross-sections of the network, and at the end of week 5, to obtain the aggregated network. The data was coded into matrices in UCINET 6.0. SNA measures were calculated for each cross-section in UCINET 6.0 and radial diagrams were generated in Social Network Visualizer 2.3.

Stage 2 – Static and temporal analysis: Firstly, we examined the radial diagrams of weeks 1 & 2 and weeks 3 & 4 shown in Table 15. The nodes (students) on the extreme periphery represent the isolates, i.e. students who either did not make a blog post or did not receive or post a response to others. In weeks 1 & 2, only 34 (79%) students engaged (interacted) in the blogging activity. This is indicated by the large number of isolates. Within the students that did engage, the network appears dense, with an equal distribution of ties, decentralized and with no clear core-periphery structure. In weeks 3 & 4, 33 (77%) of students engaged in the blogging activity and while the network appears dense, a large number of students are placed on the inner periphery with only one student in the centre of the network therefore, the centralization remains low. However, the ties do not appear to be equally distributed. At this point, based on visual inspection of the radial diagrams, it is difficult to arrive at a preliminary conclusion regarding the type community formed based on parameters in the IMF. Therefore, we need to

examine the SNA constructs corresponding with the diagrams. Looking at the SNA constructs in Table 15, we see that both weeks 1 & 2 and weeks 3 & 4 cross-sections have a very low average degree. This is owing to the large number of isolates. If we consider the average degree within the one large component (engaged students), the average degree is relatively high (1.9 for weeks 1 & 2 and 1.7 for weeks 3 & 4). Both networks have only 2 nodes in the core. The core changes from one cross-section to the other indicating legitimate peripheral participation. The reciprocity, indicative of mutual exchange, and transitivity, indicative of information flow and power dynamics are low thereby implying that the network is restrictive. This is expected in a blogging network (see section 4.3). Both networks have low centralization and only 2 cliques. In summary, the networks embody some features of a CoI (high average degree within the large component and low centralization as well as some features of a CoP (evidence of legitimate peripheral participation and low transitivity). The low number of cliques corresponds with neither a CoP or a CoI. Therefore, we conclude that in weeks 1 & 2 and weeks 3 & 4, the blogging activity does not bring the students together to form either a CoP or CoI. We now turn to the aggregate (cumulative interactions over 5 weeks) network to assess the overall community formed, if any, at the end of the blogging activity.

Table 15. Successive Cross-Sectional Networks Over 5-weeks

Weeks 1 & 2		Weeks 3 & 4		Weeks 1 – 5 (Aggregate)	
					
No. of ties	65	No. of ties	57	No. of ties	152
Average degree	0.036	Average degree	0.032	Average degree	3.5
Centralization	9.21%	Centralization	8.04%	Centralization	5.2%
Components (n>1)	1	Components (n>1)	1	Components (n>1)	1
Nodes in largest component	34	Nodes in largest component	33	Nodes in largest component	38
Cliques (n=3)	2	Cliques (n=3)	2	Cliques (n=3)	45
Core nodes	P10, P35	Core nodes	P14, P41	Core nodes	P2, P10, P35
Reciprocity	5.3%	Reciprocity	3.7%	Reciprocity	7.0%
Transitivity	3.1%	Transitivity	2.1%	Transitivity	3.3%

Stage 3 – Aggregate analysis: Visual inspection of the aggregate radial diagram and examination of corresponding SNA constructs (Table 15) reveal a dense, equally distributed network with low centralization and small core. There are very few isolates. The high number of cliques indicates mutual exchange between specific students rather than in the overall network as is reflected by the low reciprocity. The low reciprocity and transitivity is expected from a blogging network. Based on the parameters in the IMF, we can conclude that the blogging activity leads to the formation of a CoI overtime.

Stage 4 – Qualitative analysis: Having established the presence of a CoI, selective qualitative analysis needs to be conducted to address questions such as: What is the relationship between participation in a CoI, individual properties of key nodes and learning? What is the relationship between individual nodes characteristics and the nature and quality of interactions? What pedagogical conclusions can we draw from our findings? Detailed analysis of the data is ongoing.

For additional detailed case studies on identification of a CoP and CoI using the IMF see (Jan & Vlachopoulos, 2018; Jan, 2018).

5.7 Discussion

The key motivation behind development of the IMF was to address the lack of quantitative research using the CoP and CoI frameworks in HEOL. The inherent structural similarities between networks and communities logically steered us towards exploring the use of SNA to investigate CoPs and CoIs in HEOL. A detailed review of literature (Jan, Vlachopoulos, & Parsell, 2019) confirmed the lack of a theoretically grounded framework integrating SNA with the CoP and CoI frameworks. We recognize and acknowledge the limitation of the IMF in that it only considers structural characteristics of a CoP and CoI both of which are much more complex structures with several other properties. However, in terms of structural conceptualization of a CoP and CoI and operationalization of SNA measures, we feel the IMF is a good starting point as it provides an effective lens for structurally differentiating between and identifying a CoP and CoI, a task that has been difficult to date.

Practical implications of the IMF extend to researchers, lecturers/facilitators, instructional, educational and/or learning designers and even students. The IMF, which comprises of the visual illustration (Figure 5) and four sequential components (Figure 6), provides an effective methodology for assessing learner engagement during a learning activity enabling appropriately

planned intervention. It also allows for a holistic assessment of design elements that may or may not lead to formation of a specific type of community during or after activity completion. For instance, if an activity is designed with the intention of bringing students together to form a CoP, using the IMF, the structure of a cross-sectional network extracted at different points during the activity can reveal if a CoP is in-fact being formed or not. If a CoP is not identifiable, the facilitator can pull specific students (nodes) towards the centre of the network by reaching out to them in the hope of altering the structure and dynamics of the network. The impact of the intervention would of course need to be assessed by looking at the cross-sectional network post-intervention. So, while the actualization of the intended learning design cannot be orchestrated (Wenger, 1998), pedagogically informed analytics allows some room for influencing the realization of the intended design. Such a response to emergent conditions falls under the realm of the newly emerging field of designed-based research (Bower, 2017).

In terms of limitations, while the IMF reduces the need for qualitative analysis for exploring a CoP and CoI, creating matrices from interactional data from a LMS and generation of the radial network diagrams can be fairly time consuming. However, automating the process of data extraction and manipulation would eliminate this limitation making the framework usable by practitioners other than researchers. We would also like to acknowledge that the IMF does not claim that learning within one particular type of community is better than another, or even that community-based learning is more effective than otherwise. The framework was developed based on the historically established significance of communities of learning. As it stands, the functionality of the IMF is ideally suited to learning design and analytics researchers and practitioners who wish to identify and interpret CoP and/or CoI in HEOL using SNA. To date, the reliability and validity of the IMF has been tested in four case-studies (e.g. Jan & Vlachopoulos, 2018 [Chapter 6]). The framework is being tested further in ongoing research.

In conclusion, having articulated the theoretical assumptions of how a CoP and CoI can be explained using SNA, described and demonstrated application and interpretation of selected SNA constructs, and discussed practical applications and limitations of the methodological framework, we propose the IMF as a guide for identification of communities of learning in HEOL.

6. Chapter VI: Influence of Learning Design on the Formation of Online Communities of Learning (Paper Four)

Jan, S. K. & Vlachopoulos, P. (2018). Influence of learning design on the formation of online communities of learning. *International Review of Research in Open and Distance Learning, 19*(4). https://doi.org/10.19173/irrodl.v19i4.3620

Foreword

In the previous chapter, I presented the IMF, a SNA based methodological framework for investigating and identifying CoPs and CoIs in HEOL. In this paper I demonstrate the application and interpretation of the IMF in a detailed case-study on a purely online course offered at an international university. Note that I was not involved in the data collection for this case-study, neither did I conduct the qualitative analysis herein. I was provided with raw interactional data extracted from the discussion forums within the LMS. My contribution to this case-study includes preparation of the data, application and interpretation of the IMF, and interpretation of findings from the qualitative analysis in relation to the IMF. My principal supervisor, who is the co-author of this publication, was involved in the data collection for the case-study however, the qualitative analysis was conducted by external researchers. The content of the paper including the literature review, analysis, discussion, etc. was primarily produced and written by me with constructive feedback from my supervisor. As mentioned in the foreword to the previous chapter, this paper was published prior to formalisation of the stages of application of the IMF therefore, the order in which the IMF is applied does not follow the sequence described in the previous chapter however, the application and interpretation of the framework is not impacted by this.

6.1 Abstract

This paper presents the findings of a study on a fully online Bachelor's level course in Health Sciences at a European University conducted to explore the influence of learning design on the formation and evolution of different types of communities of learning. The impetus for the study came from the well-established effectiveness of community-based learning, a need for understanding learning design and analytics within networked structures and, the lack of theoretical grounding for social network analysis (SNA) in previous literature. Our study uses the Integrated Methodological Framework (IMF) which employs SNA as the key methodology for exploring community-based learning in light of the Communities of Practice (CoP) and Community of Inquiry (CoI) frameworks. The course comprised of three differently designed successive discussion forums spanning three weeks each. Network diagrams and SNA measures clearly showed the impact of the different learning designs on student engagement in the discussion forums. Based on CoP and CoI structural components within the IMF, a comparative analysis of whole-network properties of the three networks indicated the formation of a CoP, initiated and mediated by the tutor in discussion 1, sustained by the students in discussion 2, and disintegrated due to lack of guidance and facilitation in discussion 3. Qualitative analysis on the content of discussion posts revealed the importance of group oriented messages in the formation of the CoP. The paper discusses findings in terms of implications for learning design and analytics in online learning and the role of the tutor in community formation.

6.2 Introduction

Learning within networked structures, such as communities, is increasingly being considered as the most effective way to learn in the 21st century (De Laat, 2012; Dawson & Siemens, 2014). Engaging learners meaningfully is one of the fundamental guiding principles in designing for networked learning (Boud & Prosser, 2002). A networked learning environment that directs learning processes towards deep learning can be designed but the actual learning or learning experience that occurs cannot be prescribed (Goodyear, Banks, Hodgson, & McConnell, 2004; Wenger, 1998). Learning designs indicate and execute the designer's pedagogical intentions but cannot control student perception and consequent actualization of the intended design. Neither do learning designs identify how students engage in the design during or after a learning activity (Lockyer, Heathcote, & Dawson, 2013), this being a function of learning analytics. Therefore, to inform teaching and learning practice within networked structures, the inseparable iterative

relationship between learning design and analytics must be cultivated especially since the proliferation of anywhere, anytime, online learning and consequent access to "big data" from learning management systems (LMS). In a recent book, Carvalho, Goodyear, and De Laat (2017) identify the critical need for understanding approaches to analysis and design for networked learning. Social learning analytics, specifically, social network analysis (SNA), has been used considerably to investigate online networks and communities (Cela, Sicilia, & Sanchez, 2015); however, researchers have pointed to the lack of theoretical grounding for the SNA, which makes pedagogical interpretation and application of findings difficult (De Laat & Prinsen, 2014; Shea et al., 2013). This paper attempts to contribute to research on learning design and analytics in the context of higher education online learning (HEOL) by investigating the influence of learning design on the formation and evolution of communities of learning using the theoretically grounded Integrated Methodological Framework (IMF) (Jan & Vlachopoulos, 2018), which employs SNA as a central methodology. In a case study involving three differently designed discussion forums, the IMF is used to investigate the type of community formed in each discussion activity and the key factors that contribute to the formation of the community. The paper begins by a brief overview of the significance of, and design for, community-based learning. Following this, the case study is presented, findings are reported, and finally practical pedagogical implications for learning design and analytics in the context of HEOL are discussed.

6.3 Literature Review

6.3.1 Community-Based Learning

The terms *network* and *community* are frequently used interchangeably in literature on online learning despite the different educational affordances of the structures. Briefly, a network is defined as, "A set of connections among people, whether or not these connections are mediated by technological networks. They use their connections and relationships as a resource in order to quickly solve problems, share knowledge, and make further connections" (Wenger, Trayner, & De Laat, 2011, p. 9). On the other hand, "A community is a group of individuals identifiable by who they are in terms of how they relate to each other, their common activities and ways of thinking, and their beliefs and values" (Biza, Jaworski, & Hemmi, 2014, p. 162). While a network is simply a group of entities joined together by relationships, a community takes time to form. The effectiveness of community-based learning is a widely-held belief resting on decades of research. The pedagogical foundations for learning communities lie in Dewey's (1980-1904)

concept of student-driven learning via engagement, active learning and, collaboration (Fink & Inkelas, 2015). The precursor of the learning community dates to the 1920s when the "experimental college" program was introduced by Alexander Meiklejohn (Smith, 2001). The 1960s saw a rebirth of this idea which gained further momentum in the 1980s with the recognition that learning in a community leads to higher levels of learning and development (Zhao & Kuh, 2004). This momentum continued into the 1990s with several studies reporting links between participating in learning communities and favourable outcomes for college students (Matthews 1994; Pike, 1999; Tinto, 1998). Onwards, with the pervasiveness of online learning and the interactivity afforded by Web 2.0 technologies, learning in communities became the holy grail of online learning as stated by Palloff and Pratt (1999), "without the support and participation of a learning community, there is no online course" (p. 29). Kop and Hill (2008) state that "the starting point for learning occurs when knowledge is actuated through the process of a learner connecting to and feeding information into a learning community" (p. 1). With the development of frameworks, such as, Communities of Practice (CoP) (Lave & Wenger, 1991; Wenger, 1998) and Community of Inquiry (CoI) (Garrison & Anderson, 2003), the last two decades have seen an explosion of research on learning communities re-affirming that learning in communities is the way to learn. Given the effectiveness of community-based learning, can we assume that students, in a course of study, whose learning is embedded within online networked structures, naturally form a community of learning? If a community is not formed naturally, can a particular type of learning design influence the formation of a specific type of community?

6.3.2 Designing for Online Communities of Learning

The use of the term learning design is contested in literature and to date there is no one agreed upon definition of what constitutes learning design. For instance, Agostinho, Oliver, Harper, Hedberg, and Wills (2002) refer to learning design as "the sequence and types of activities and interactions that are selected to shape the student learning experience" (p. 3). Donald, Blake, Girault, Datt, and Ramsay (2009) define learning design as a product that "documents and describes a learning activity in such a way that other teachers can understand it and use it (in some way) in their own context" and as a "process by which teachers design for learning, when they devise a plan, design or structure for a learning activity" (p. 180). Conole (2012) refers to learning design as a "methodology for enabling teachers/designers to make more informed decisions in how they go about designing learning activities and interventions..." (p. 7). Regardless of whether learning design is considered as a sequence, a product, a process, or a

methodology, in HEOL the basic components of learning design remain the same. The learning environment comprises of the LMS, tools and technologies, content or curriculum, individuals and their roles (lecturer, tutor, student, support staff, etc.), and some other resources. A good learning design framework is expected to bring together these components in a manner that leads to the desirable learning outcomes. In the Activity-Centred Analysis and Design (ACAD) framework, Carvalho and Goodyear (2014) discuss three structures of learning design, i.e. set design (space, place, artefacts, tools, etc.), social design (dyads, groups, roles, communities, etc.), and epistemic or intended design, which intermingle to create the actual activity or learning that emerges organically and cannot be manipulated by design. In a similar vein, referring to communities of learning, Wenger (1998) speaks of learning as something "that cannot be designed but can be designed for" (p. 229), i.e. one can create a design with the intention of forming a community; however, there is no guarantee that the community will form. Good learning designs are seldom static and can be altered, as needed, as a course of study progresses. However, once an activity, for example a discussion forum, has commenced, it must be seen to completion and the only changes that can be made to the design are through intervention (moderation) by a facilitator during the activity. Therefore, the role of moderation or facilitation forms a crucial component of online learning activities, and as such, has been the subject of substantial research over the past two decades. However, the impact, if any, of moderation on the formation of a specific type of community of learning remains unknown.

6.3.3 The Role of Facilitation in Community Formation

Numerous frameworks and models for online tutoring and e-moderation have been developed over the past couple of decades; however, most do not provide a clear a definition of e-moderation and online facilitation (Vlachopoulos & Cowan, 2010). The CoI framework (Garrison & Anderson, 2003), Salmon's (2000, 2003) 5-stage model of e-moderation and the ring-fence e-moderation framework (Vlachopoulos & Cowan, 2010) being the exception. The CoI framework comprises of three interconnected presences, social presence (SP), cognitive presence (CP), and teaching presence (TP). In a CoI, the role of the facilitator (lecturer or tutor) lies within TP. Teaching presence is not limited to facilitators and can be assumed by anyone, e.g., an actively engaged student.TP does not only encompass subject expertise but also includes design and facilitation of the learning environment such that a CoI would be created over the course of study (Anderson, Rourke, Garrison, & Archer, 2001). The essence of the role of the tutor in the CoI framework includes developing a sense of community amongst students by advancing social

relationships (SP), among other things. (Garrison & Anderson, 2003). SP modelled by the tutor or lecturer encourages student engagement as students feel acknowledged and visible (Rourke, Anderson, Garrison, & Archer, 2001; Stacey, 2002, Shea & Bidjerano, 2010). However, SP and TP by themselves are not enough for deep and meaningful learning for which CP is critical. In a CoI, the facilitator should guide students to develop meaning, confirm understandings, integrate knowledge, and arrive at resolutions (Garrison & Cleveland-Innes, 2005). In a different vein, Salmon's (2000, 2003) 5-stage model of e-moderation describes a tutor as someone who progressively engages students in constructivist learning but who is not necessarily the subject expert. Like the CoI framework, Salmon's model is limited to online social learning; however, the model does not specifically concern community development (Moule, 2007). A community literally means, "a unified body of individuals" (Merriam-Webster, 2017) so when we think of a community of learning, it is natural to envisage a tightly-knit group of students. Based on this we can assume that a facilitator who intends to form a community of learning would aim to keep students tightly-knit towards the centre of the community. The ring-fence e-moderation framework (Vlachopoulos & Cowan, 2010) comes closest to this idea postulating that e-moderation should be contained within "an enclosed learning arena" in which the learning is "student-centred and implicitly student-directed" (p. 31), and that distinctly encapsulates student and e-moderator activities only. Acknowledging that the tutor's activities within the ring-fence are influenced by predetermined outside and emergent inside factors, the framework clearly describes the role of the tutor as: identification of a significant posting; construction and posting in alignment with the tutor's style, purpose, and desired learning positions; and influencing, but not directing, student progress. There are several guides and books on best practices for online facilitation and moderation (Vlachopoulos, 2012); however, the role facilitation does and/or can play in the formation of a specific type of community of learning has yet to be investigated.

6.4 Research Questions

Considering the long-standing effectiveness of community-based learning and the gap in understanding design for community-based learning, especially the role of facilitation in community formation, we explore the influence of learning design on the formation and evolution of online communities of learning by specifically addressing the following questions: Given different learning designs of the same learning activity, can we identify the type of community formed within each design, if any, using SNA? If a specific type of community is

formed, how does it evolve? And what are some of the key factors that contribute to the formation and evolution of the community? What practical pedagogical implications can we draw from our findings?

6.5 An Online Community of Learning – A Case Study

6.5.1 Context of the Study

The study was conducted on a fully online Bachelor's level course in the Health Sciences at a European University. The cohort comprised of a total of 20 students (13 female, 7 male) aged between 26 and 54 years. The students were qualified healthcare professionals who took the course to enhance their critical thinking skills and professional practice. The course comprised of three differently designed, successive discussion forums spanning 3 weeks each. Discussion 1 was guided and facilitated by the tutor who acted as the subject expert. In discussion 2, students were asked to discuss a practice online, for instance, something they did in the hospital, and exchange advice drawing on personal experiences. Discussion 3 was designed as a free-flowing discussion in which students could raise anything they wished in relation to the course or their practice. This discussion was not graded. The discussions were threaded with nested messages within each thread. Interaction data for each discussion activity was extracted from the LMS (Moodle) for analysis. All students had prior experience with online discussions as a way of learning and development as they had completed other online professional development courses at the same University. As such any maturation effect was not considered to be a methodological issue.

6.5.2 Analytical Framework for the Study

We use the Integrated Methodological Framework (IMF), shown in Figure 7, to conduct our investigation. The IMF uses SNA as the key methodology for identifying and exploring communities in higher education online learning (HEOL). The IMF embeds SNA in structural components of empirically tested and well-established CoP and CoI frameworks and includes selective qualitative analysis which supports the SNA. Definition of a CoP and CoI, explanation of the structural components of a CoP and CoI, and details on development and application of the IMF, can be found in Jan and Vlachopoulos (2018).

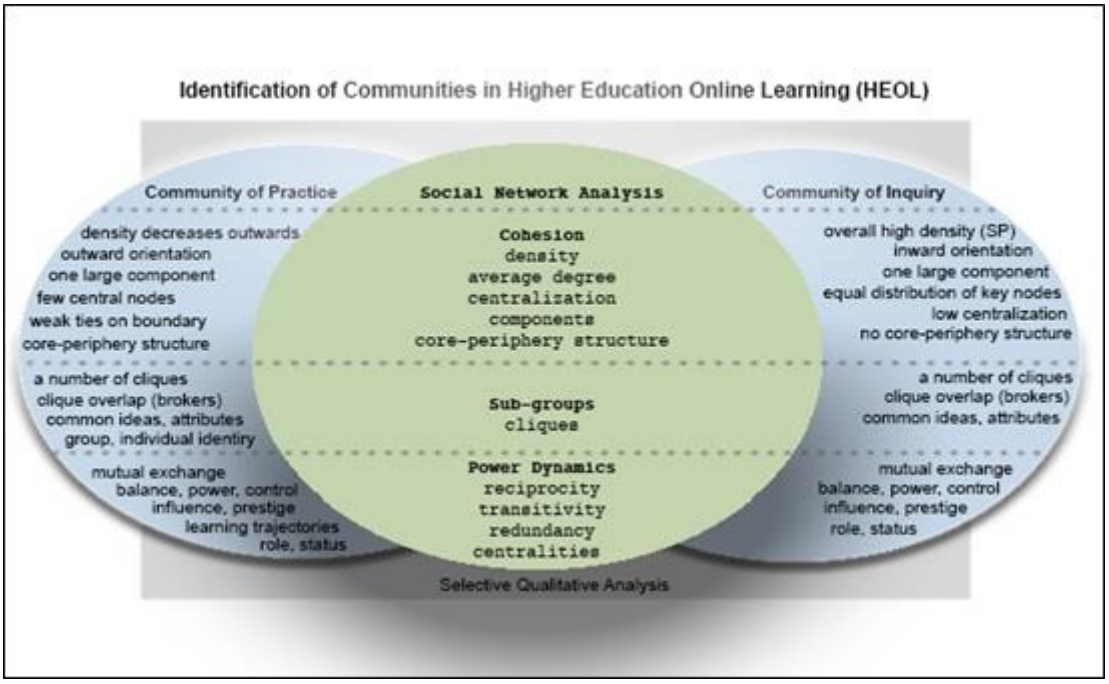


Figure 7. Integrated Methodological Framework (IMF)

6.5.3 Findings from Social Network Analysis

Data was coded into matrices for SNA which was conducted in Ucinet 6.0 (Borgatti, Everette, & Freeman, 2002). The rows and columns of a matrix represented the nodes in the networks, i.e. the students and tutor. A value of 1 indicated an interaction (a direct response or reply to a message) between two nodes and 0 indicated no interaction. Multiple interactions between the same nodes were treated as one. The resulting networks were directed, indicating the initiator of each interaction, but not-weighted. The network diagrams shown in Figure 8 below were generated in Social Network Visualizer 2.3 (Socnetv, 2017).

The nodes in the network diagrams represent the 20 students and one tutor (shown in green) who was also the subject expert. The nodes are positioned within the networks based on the overall degree centrality of each node. The networks of discussion 1, 2, and 3 represent all interactions over the 3-week period of each discussion activity. The aggregated network shows all interactions over the total 9-week period. Exploration of community formation and evolution using the IMF is a multi-stage process. First, we need to look at the structure of cross-sectional networks on a stand-alone basis. Cross-sectional networks are snapshots of interactions at a certain point in time, for instance, in Figure 2 the network diagrams of discussions 1, 2, and 3 are a cross-sectional representation of interactions at the end of each 3-week period. Second, to explore temporal dynamics of communities, we need to look at changes in the structure of the

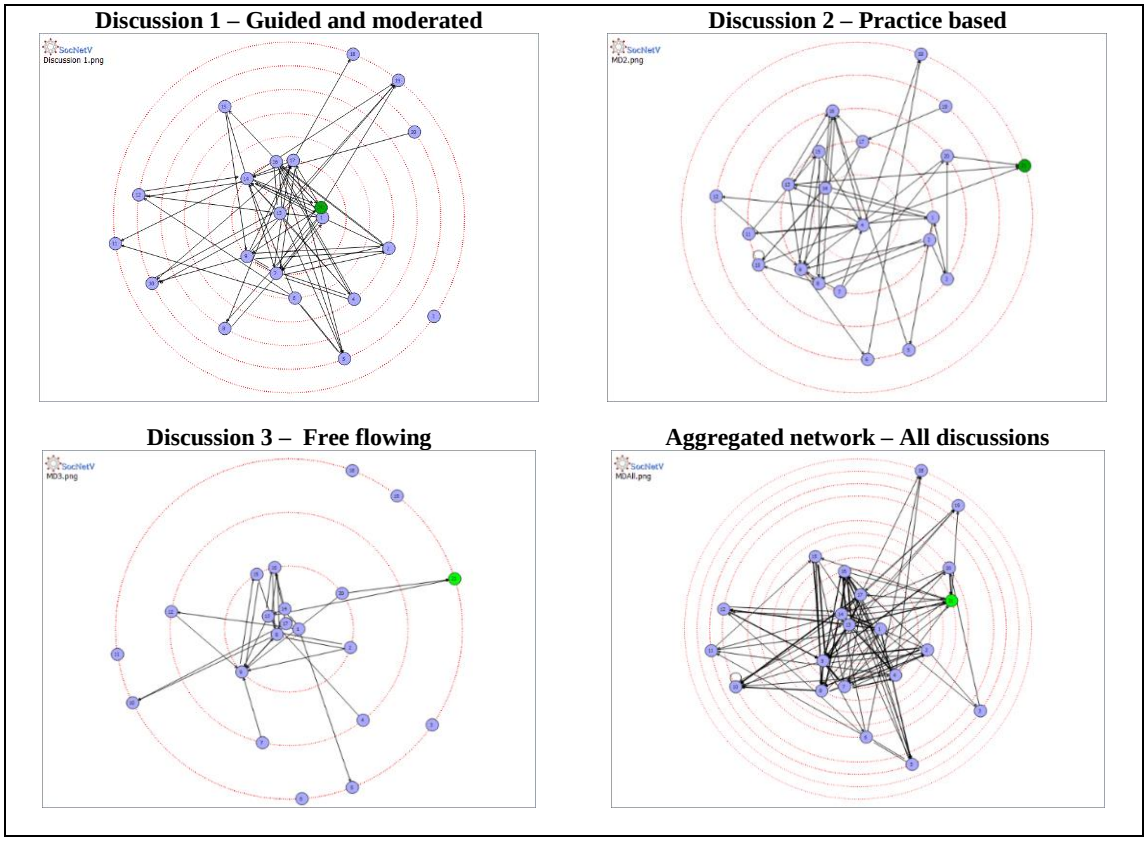


Figure 8. Discussion networks based on degree centralities

successive cross-sectional networks. Finally, we need to examine the aggregated network which captures cumulative interactions over the entire period under consideration. Although the aggregated network does not reveal community dynamics, the overall structure of the network indicates the global orientation of the community.

We begin our investigation into community formation and evolution by examining each network diagram from Figure 2 using constructs from the IMF. In discussion 1, the network comprises of one fully connected component. The density of the network decreases outwards from the centre depicting weaker ties on the periphery and a clear core-periphery structure is visible. The tutor, who is the subject expert and moderator, appears highly central along with a few other students. In discussion 2, corresponding with the design of the discussion activity, i.e. practice-based and not moderated, the tutor moves out of the core to the periphery. While the network remains fully connected within one component, it is relatively less dense. However, we still see a core-periphery structure as the density decreases outwards from the centre. In the free-flowing

discussion 3, the network structure changes significantly as the number of interactions and density decline and the network becomes disconnected. The core-periphery structure remains somewhat with the same number of nodes in the core as discussion 2; however, a few isolates appear on the periphery along with the tutor. Based on the overall structure of the networks depicted in the network diagrams, we conclude that the learning design of discussion 1 and 2 lead to the formation of a CoP; however, as a consequence of the design of discussion 3, the CoP is not able to sustain itself fully in discussion 3 and begins to disintegrate. If we consider the aggregated network, again a CoP structure is observed owing to the fully connected large component, greater density towards the centre, and a clear core-periphery structure in which the tutor is positioned towards the outer boundary of the core with a few students taking on central roles implicating development of subject expertise.

Having identified the networks as a CoP, further analysis is restricted to the CoP portion of the IMF. A key component of a CoP is the notion of legitimate peripheral participation (LPP) in which newcomers enter a community and progressively move to the core from the periphery replacing old-timers or experts as the newcomers learn and develop identities (Lave & Wenger, 1991). LPP signifies the learning process which culminates into the learning experience or identity formation in CoP terminology. In the context of network structure, LPP is denoted by a changing core-periphery structure in successive cross-sectional networks as students, tutors, and/or lecturers move in and out of the core. To validate our earlier conclusion and verify LPP among other things, we need to take our investigation to the next step in the IMF. In Table 16 below, whole-network SNA measures corresponding with the network diagrams in Figure 8 are given.

Table 16

Whole-network SNA Measures for Successive and Aggregated Discussion Networks

SNA measures	**Discussion 1**	**Discussion 2**	**Discussion 3**	**Aggregated**
No. of ties	62	46	28	136
Average degree	3.0	2.2	1.3	6.5
Centralization	30.5%	28.2%	32.1%	23.6%
Components (n>1)	1	1	1	1
Nodes in largest component	20	21	16	21
Cliques (n=3)	18	7	3	33
Core nodes	1,7,9,13,14,16,17,21(T)	4,8,9,13,15,16	1,8,9,13,14,16	1,7,8,9,13,14,16,17,21(T)
Reciprocity	3.2%	12%	21.7%	28.9%
Transitivity	22.6%	9.2%	11.4%	28.6%

In addition to quantifying the structural properties evident in the network diagrams, the SNA measures further reveal the structural dynamics or rhythms of the community as it re-configures itself under the influence of different learning designs. Additionally, SNA measures such as reciprocity and transitivity, implicate overall power dynamics within the community. Reciprocity is the degree of mutual exchange between nodes. Transitivity is calculated based on the percentage of transitive triads within a network. A transitive triad occurs if A is connected to B, B is connected to C, and A is also connected to C. A high transitivity indicates the presence of alternate paths for flow in a network. The higher the transitivity, the lower the power and control of central nodes. The CoP framework does not discuss issues of power and control that are critical determinants of the flow of information and resources in a community (Hughes, Jewson, & Unwin, 2007), an important consideration in the pedagogical context. For instance, a network with low transitivity and high reciprocity indicates that it is dominated by a few central nodes who are actively engaging with one another and control the flow of the network.

As shown in Table 16, with a total of 62 ties, discussion 1 consists of one large connected component consisting of 20 nodes, that is, one tutor and 19 of the 20 students. The network has a relatively high centralization (30.5%), the largest core (eight nodes), and number of overlapping cliques (n=3 is the number of nodes all of which are connected to one another). Clearly, the activity in the network is dominated by the tutor and a few select students who form tightly-knit subgroups or cliques. Interestingly, the reciprocity or mutual exchange is lowest in discussion 1 indicating that even though students are actively participating in the discussion, they are not responding to one another. On the other hand, the network has the highest transitivity at 22.6% making it less restrictive and controlled in comparison to the other networks. Generally, the transitivity is on the lower side, which implicates power and influence of the core nodes including the tutor - an outcome of the learning design. In discussion 2, the network is contained within one large component, as well with all 20 students active in the discussion. The degree of centralization drops to 28.2% as the tutor moves out to the periphery and the number of nodes in the core reduces to six. Even though the tutor is no longer active in the discussion, the CoP structure seen in discussion 1 remains intact. The core-periphery structure changes depicting LPP. Specifically, the tutor and student 1 and 7 move out of the core to the periphery, students 4, 8, and 15 join the core from the periphery while students 9 and 16 remain in the core. The number of cliques drops significantly indicating the loosening up of the structure as students reach out to other students as indicated by the high reciprocity. The low transitivity points to

greater power and control of the students in the core. Both discussion 1 and 2 form a CoP with and without tutor or lecturer involvement, therefore it appears that the practice-based nature of the discussion achieves a similar outcome as the guided and facilitated discussion 1. In the free-flowing discussion 3, the number of ties and average degree drops further and the network centralization increases to 32.1%, the highest amongst the three networks. Again, we see evidence of LPP where the tutor remains at the periphery, student 1 re-joins the core, students 4 and 15 move out of the core to the periphery, student 14 joins the core from the periphery, and students 9 and 16 again maintain their positions in the core. The reciprocity is relatively high and the transitivity remains low indicating the control and influence of the students at the core. The overall structure of the network shows remnants of a CoP which has disintegrated presumably due to the lack of guidance and facilitation.

Finally, the aggregated network also depicts an overall CoP with a large spread out core (nine nodes) which explains the relatively low centralization (23.6%). The low but equal reciprocity (28.9%) and transitivity (28.6%) indicate the active participation, mutual exchange, control, and influence of the core nodes. Despite being on the periphery in discussions 2 and 3, the tutor appears in the core of the aggregated network, which indicates the integral role that guidance and facilitation played in the formation of a CoP. Furthermore, the tutor's position in the outer-boundary of the core nicely depicts the process of LPP whereby students push out the tutor by taking on central positions within the core. In summary, the learning design of discussion 1 and 2 leads to the formation of a CoP, which is not sustained by the design of discussion 3. The guidance and facilitation provided by the tutor in discussion 1 was instrumental in the initial formation of the CoP, which was driven and sustained successfully by the students in the practice-based discussion 2. The lack of direction and tutor involvement in discussion 3 led to student disengagement and disintegration of the CoP. We now turn our attention to the final component of the IMF, i.e. qualitative analysis to support the SNA.

6.5.4 Findings from Qualitative Analysis

Using the IMF, we have identified the type of community formed based on the structural properties and dynamics of the networks. However, for a complete exploration we need to examine the nature of the interactions that bring students together into a CoP (Jan & Vlachopoulos, 2017 [Chapter 6]). For this, we conducted qualitative analysis of the content of messages posted in the discussion activities. We used the illocutionary unit (Howell-Richardson

& Miller, 1996), which focuses on the linguistic properties of the messages and the individual to whom the message is directed, as the unit of analysis. All messages were coded in terms of the type of interactions using the coding scheme given in Table 17.

Table 17

Interaction Coding Scheme

Type of interaction	Code	Criteria
Group proactive	GP	Student or tutor looks for a response from someone in the group - anyone
Group reactive	GR	Student or tutor responds to one of the above, or some other message, playing reply back to group
Individual proactive	IP	Student or tutor looks for a response from a specific contributor, or even asks for it
Individual reactive	IR	Student of tutor responds to one of the above, or some other message, from and then to a specific contributor
Quasi interactive	QI	Threaded (follow-up) message where tutor or student acknowledges previous message but continues with a new idea/concept.
Monologue	M	A new thread. No evidence of interaction with any other participant

Note: For detailed indicators of criteria refer to Author (2012).

Two researchers independently performed the coding and achieved a Cohen's (1960) Kappa interrater reliability of 72%. Figure 9 shows the types of interactions within each discussion. Of a total of 292 types of interactions, 91 occurred in discussion 1, 106 in discussion 2, and 95 in

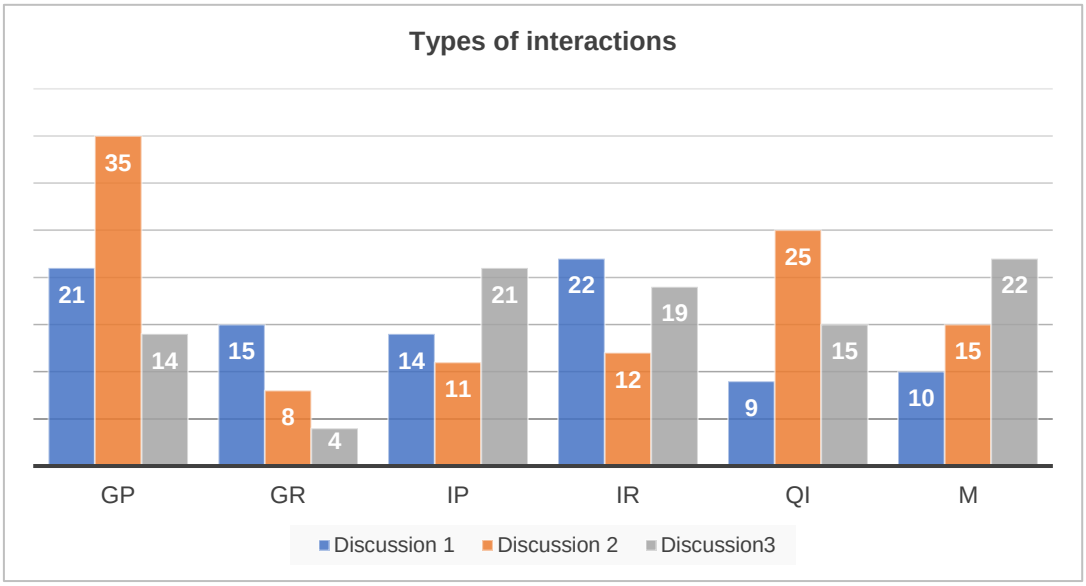


Figure 9. Types of interactions in discussions

discussion 3. Discussion 1 had the highest number of GP and an equally high number of IR interactions, which indicates that while participants addressed the entire group, they also reached out to others. However, the low reciprocity found indicates that they were not responding or reacting to each other. Discussion 2 had the highest number of GP interactions followed by the highest number of QI messages indicating that while individuals posted to the group, they were not specifically responding to messages directed to them. Again, this finding fits well with the low reciprocity found. Discussion 3 was dominated by M, IP, and IR interactions, which bodes well with findings from the SNA, i.e. there was a relatively high degree of mutual exchange (reciprocity), a few isolates, and a low level of group communication. The dominance of GP messages in discussions 1 and 2 lead us to conclude that messages directed to the entire group were a contributing factor in formation of the CoP.

6.6 Conclusion

In a CoP, individuals who share a *practice* come together as they *mutually exchange* ideas and negotiate meaning while creating a *shared repertoire* of conceptual and material artefacts (Wenger, 1998). As conceived by Wenger (1998) in its originality, a CoP is a natural occurrence and is formed whenever there is a practice, mutual engagement, and a shared repertoire. Learning, as signified by the process of LPP or identity formation, takes place within the CoP inevitably. In the context of online learning, if a CoP exists, we would expect similar patterns of engagement and learning to occur. However, in the online environment, a CoP may not form naturally and therefore needs to be artificially cultivated by design. As discussed earlier, a learning design does not have the capacity to orchestrate the learning experience or formation community but can create an environment conducive to its formation. Exploration of if and how this is achieved was the key objective of our research. In line with the research questions guiding our investigation, there are three key takeaways from our findings. Firstly, using CoP constructs from the IMF, we were successfully able to use SNA to structurally identify the type of community formed in each discussion activity by looking at the network diagrams and whole-network SNA measures. Secondly, we found that the guidance and facilitation in discussion 1 provided by the tutor was critical in setting the stage for the initial formation of the CoP. Replacing the tutors' guidance and facilitation with the practice-based design in discussion 2, maintained the structure of the community as the student-centred and student-directed discussion was able to sustain the CoP despite withdrawal of the tutor. In discussion 3, the absence of the tutor and the free-flowing, undirected design of the discussion, led to the disintegration of the CoP as student

engagement lost its momentum and the nature of the interactions changed. As found by the qualitative analysis, another key influential factor in the formation of the CoP was the type of interaction or message within the discussions. Discussions 1 and 2 were dominated by group proactive messages that addressed the entire group while discussion 3 was dominated by monologues.

In terms of practical implications for learning design and analytics in the online learning context, firstly, our findings validate the application and effectiveness of the IMF in identifying a CoP without having to conduct extensive qualitative analysis as has been the case previously (Jan, Vlachopoulos, & Parsell, 2019). Secondly, the learning designs of the successive discussions 1 and 2 act as exemplars of the sort of design that could potentially bring students and/or tutors together to form a CoP should that be the intention of the designer. Thirdly, with respect to the role of the tutor, facilitation can be planned during a course of study by generating cross-sectional network diagrams, which indicate the orientation of the network in terms of the type of community being formed. Again, if the learning design intends to create a specific type of community, appropriate facilitation or intervention can be planned to alter the underlying structure of the community, i.e. the network. Last, but certainly not the least, group proactive messages or posts seem to illicit greater engagement and response. Therefore, tutors should try to address the entire group in their posts, at least at the beginning of an activity, such as in a discussion forum.

In terms of limitations of the study, we would like to point out that the study merely examines the formation of a community of learning in the online learning context. It does not claim that learning within one particular type of community is better than another, or even that community-based learning is more effective than otherwise. Furthermore, the study does not consider the critical influence of individual attributes on individual engagement. For a more holistic exploration, further research should look at student performance and attributional data to explore the relationships between engagement within a community, individual attributes like goal orientation and self-efficacy, and performance.

7. Chapter VII: Identifying Online Communities of Inquiry in Higher Education Online Learning (Paper Five)

Jan, S. K. (2018). Identifying online communities of inquiry in higher education online learning. *Research in Learning Technology, 6.* https://doi.org/10.25304/rlt.v26.2064

Foreword

In this chapter, I present a second detailed case-study to demonstrate the application and interpretation of the IMF. I conducted this case study on two sequential offerings of a purely online course at Macquarie University. Before data collection for the first offering, I met with the lecturer of the course to discuss the learning design of the course and his intentions behind including facilitated weekly discussion forums in the course. The lecturer indicated the weekly discussion forums were intended to engage students and the tutor (the facilitator) in a CoI. With that in mind, I first applied the IMF to interactional data from the discussion forums in the first offering of the course. Then, I shared my findings with the lecturer based on which he asked the tutor of the second offering, which was a compressed version of the course, to be more proactive in facilitating the course. Again, I applied the IMF to interactional data from the discussion forums in the second offering and was very pleased with the findings which demonstrated the capacity of the IMF to reflect the differences in the learning design of the two offerings. I would like to mention that besides discussing findings from the first offering of the course with the lecturer, I was not involved in the design and delivery of either of the two offerings. Therefore, the data obtained is impartial and the analysis is replicable.

7.1 Abstract

This article presents findings from a case study on a fully online bachelor's level course at an Australian University. The study was undertaken to demonstrate the effectiveness of the integrated methodological framework (IMF) in structurally exploring and identifying online communities of inquiry (CoI). The IMF employs social network analysis (SNA) as the key methodology for exploring community -based learning in light of the communities of practice (CoP) and CoI frameworks. The case study was conducted on two offerings of the same online course with some variations in the design. In line with the intentions of the lecturer to engage students in a CoI, the course included guided, facilitated, and graded weekly discussion activities. On application of the IMF, network diagrams and SNA measures clearly showed the impact of the different learning designs on student online engagement within the discussion forums in each semester. Based on structural components of a CoI within the IMF, a comparative analysis of the networks obtained indicated the formation of an unidentified community in S2 and a CoI in S3. The article discusses findings in terms of effectiveness of the IMF, impact of learning design on community formation and learning analytics in online learning.

7.2 Introduction

Since its inception, the community of inquiry (CoI) framework (Garrison, Anderson, and Archer 2000) has been applied extensively for practice and research in online and blended learning (Garrison and Arbaugh 2007; Kineshanko 2016). Reporting on research between 2000 and 2011, Halverson et al. (2013) state, 'the Community of Inquiry framework seems to be one of the most utilized theories for blended learning…' (p. 24). Prior to the development of the CoI survey (Arbaugh et al. 2008), research using the CoI framework relied exclusively on extensive and time-consuming qualitative analysis of online discourse transcripts between participants (lecturers/ tutors and students). Since the introduction of the CoI survey, a mix of qualitative and quantitative analysis has been used for investigating CoIs. More recently, social network analysis (SNA) has also been applied as an analytical tool in conjunction with other methodologies for exploring CoIs; however, application of SNA has been limited and lacks appropriate pedagogical grounding (Jan and Vlachopoulos 2018). The importance of qualitative content analysis in CoI

research cannot be overstated; however, 'there is a need to refine research methodologies for effective assessment of things within a CoI such as group cohesion, inquiry progress and direction' (Garrison 2017, p. 165). Assessing a CoI over time through qualitative content analysis is difficult and challenging (Jokismovic et al. 2014); however, such an evaluation is required for formative diagnostics, timely intervention (Garrison 2017) and response to emergent conditions during a learning activity (Bower 2017).

Cognisant of this need, and recognising the untapped potential of SNA, the integrated methodological framework (IMF) (Jan and Vlachopoulos 2018) was developed to allow for structural exploration and identification of communities of learning in higher education online learning. The IMF came about from findings of a systematic literature review (Jan, Vlachopoulos, & Parsell, 2019 [Chapter 3][5]) conducted in search of studies that integrate SNA with community-based pedagogical frameworks, namely the CoI and CoP frameworks. The IMF embeds SNA in structural components of a CoI and CoP and allows for identification of communities of learning at the whole-network (macro) and individual (micro) level, thereby achieving the dual purpose of theoretically grounding SNA constructs and providing a means to qualitatively assess a CoI and CoP. The IMF has been applied in (Jan & Vlachopoulos, 2018a [Chapter 5]) and (Jan & Vlachopoulos, 2018b [Chapter 6]) and further testing is ongoing. The goal of this article is to demonstrate the effectiveness of the IMF in identifying an online CoI at different points in time during a course designed with the intention of engaging students in a CoI. The case study consists of two offerings of the same online course over successive semesters with slight variations in course design. By comparing findings from each offering, the case study aims to validate the capacity of the IMF to capture the impact of the different learning designs on the formation of a CoI, thereby proving to be an effective framework with practical applications for research, assessment, diagnostics and intervention. The article begins by providing an overview of the CoI framework, research methodologies commonly used in investigating a CoI and an explanation of the structural characteristics of a CoI. An outline of the IMF and research questions follow this. Finally, the case study is presented and findings discussed.

[5] The second systematic review (Jan, 2018) is not referenced here as it was written after this paper was published.

7.3 Theoretical Framework

The CoI framework is based on the collaborative constructivist view of teaching and learning which situates learning in the interplay between social and individual production of knowledge. With its roots in Dewey's (1859–1932) ideas on critical thinking, collaborative learning and practical inquiry, and Vygotsky's (1978) view of learning as a transaction between individuals and society, the CoI framework was developed as a guide for online pedagogical practices and research (Garrison 2017). The CoI framework is a learning-centred, process-based model driven by the continuous interactions between three intersecting presences: social presence (SP), teaching presence (TP) and cognitive presence (CP). SP is defined as 'the ability of participants in a community of inquiry to project themselves socially and emotionally as "real" people…' (Garrison, Anderson, and Archer 2000, p. 94). CP is 'the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse' (Garrison, Anderson, and Archer 2000, p. 89), and TP is described as a presence that 'manages the environment and focuses and facilitates learning experiences' (Garrison and Kanuka 2004, p. 98). Each presence comprises of a sequence of interdependent stages that interact progressively and create the learning experience. In the seminal article introducing the CoI framework, Garrison, Anderson and Archer (2000) present a coding template with indicators for identifying SP, CP and TP in text-based communication. Along with this, three other supporting publications (Anderson, Rourke, Garrison, & Archer, 2001; Garrison, Anderson, and Archer 2001; Rourke et al. 1999) form the crux of the CoI framework.

Prior to the development of the CoI survey, research based on the CoI framework was predominantly qualitative in nature and focused on individual presences rather than the entire framework (Arbaugh et al. 2008). Much of the earlier research on the framework centred on defining the structure of the three presences. This later shifted to understanding the relationships between the presences and then to investigating intra-presence dynamics (Garrison 2017). In a thematic synthesis of CoI based empirical studies published between 1999 and 2014, Kineshanko (2016) found that the largest percentage (39%) of the 329 artefacts examined in detail were on one or two specific presences. The inter-relationships between SP, TP and CP are complicated, not yet fully understood, and are the subject of ongoing research. Garrison (2017) consolidates the current state of knowledge regarding the dynamics between the presences. Summarising, research confirms that SP is an integral precursor to CP which includes collaboration and critical discourse, and CP is enhanced and sustained when SP is established. SP

is also the foundation that sustains the community after it has been formed by functionalities that lie within TP, and TP is necessary to sustain participation. A CoI must involve full and open communication as over time, high levels of SP are replaced by TP and CP as participants assume different roles and responsibilities. Each participant in a CoI embodies each presence, and the presences evolve mutually.

In terms of the structural characteristics of a CoI, group cohesion or degree of interactions between participants is a component of SP which is always present in a CoI (Garrison 2017); therefore, SP is the backbone of the community. Hence, an ongoing assessment of a CoI must include examination of engagement between participants in the network of online interactions. If group cohesion is a component of SP, it can be reasonably assumed that the overall density of the interactional network represents the level of SP in a CoI. Recent studies (Shea and Bidjerano 2010; Tirado, Hernando, and Aguaded 2015) have validated this assumption. Therefore, as a starting point in the assessment and identification of a CoI, the overall configuration of the interactional network is taken to be representative of the degree and distribution of SP which is the underlying presence of CP and TP as well.

7.4 Analytical Framework

Figure 10 shows the integrated methodological framework (IMF) for structural exploration and identification of communities of learning in higher education online learning using SNA as the key methodology. The framework provides pedagogical grounding to SNA by embedding SNA constructs within the structural components of the CoI and CoP frameworks. Additionally, the IMF includes the support of selective qualitative analysis which may or may not be required depending on the context and depth of investigation. Specific SNA constructs have been selected for inclusion in the IMF based on their appropriateness with parallel structural components of a CoI and CoP. Note that the IMF is flexible and adaptable to different contexts (discussion forums, blogs, wikis, etc.) and should be interpreted accordingly. For further details including definitions of SNA constructs, development and application of the IMF, please see (Jan and Vlachopoulos 2018 [Chapter 5]).

As shown in Figure 10, network cohesion, centralisation, core-periphery structure, number and size of components and cliques, reciprocity and transitivity measures are used to structurally identify a CoI. In a CoI, one would expect to see dense networks (signifying SP) throughout with

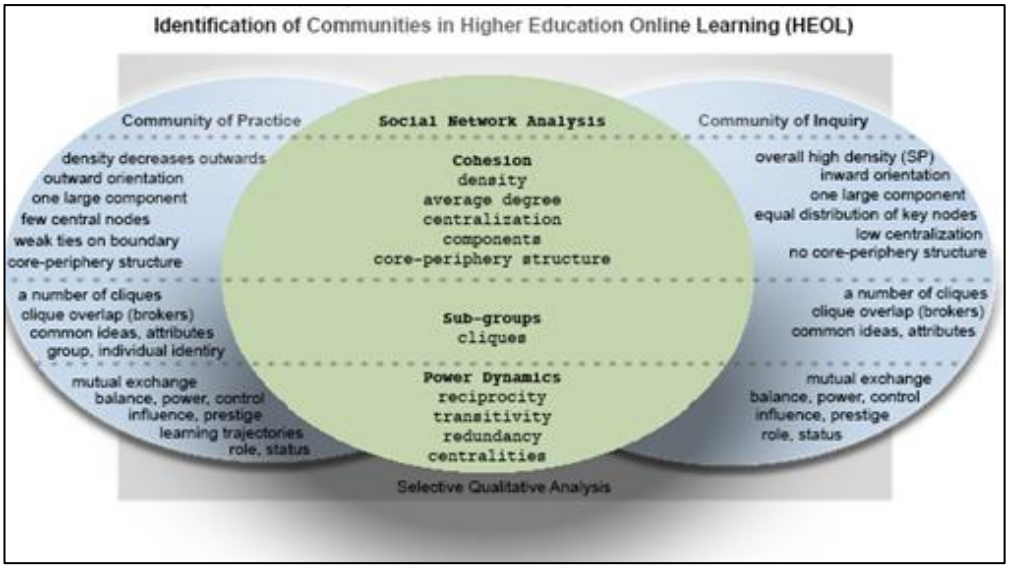


Figure 10. Integrated Methodological Framework

relatively equal distribution of ties and key nodes across the network; therefore, the centralisation would be low. There would be no clear core-periphery structure and participants would ideally be connected within one large component. The number of isolates would be low representing full communication. There would be large number of cliques representing closely-knit groups with high mutual exchange (reciprocity) and high transitivity signifying an open, non-restrictive network in terms of information flow. The key assumption underlying this interpretation is that since SP is the foundation for CP and TP, and the configuration of connections in a network represent SP, the balanced distribution of SP is critical for the existence of a CoI.

7.5 Research Questions

The key objective of this article is to demonstrate the effectiveness of the IMF in identifying an online CoI. By applying the IMF and comparing findings from two successive offerings of the same online course with slight variations in design, the case study aims to validate the IMF as a valuable methodological framework for structurally exploring and identifying a CoI. For each offering of the course, the case study uses the IMF to determine the following: Can a CoI be structurally identified at different points in time during the course? Does the design of the course lead to the

formation of a CoI at the end of the course? What practical pedagogical implications can we draw from the findings? The study has been approved by the University's Ethics Review Committee, reference number 5201600892.

7.6 Context of the Study

The study was conducted on an online course in the Faculty of Arts over semester 2 (S2) and semester 3 (S3) at a large metropolitan university in Australia in 2017–2018. Moodle was used as the LMS for the course. The course curriculum, content, learning tools and activities were identical in S2 and S3. To inculcate a sense of community amongst the students, the lecturer chose weekly discussion forums as the preferred tool for online interaction of the students (Andresen 2009). To encourage online engagement and generate extrinsic motivation (An, Shin, and Lim 2009; Rovai 2007), participation in the discussion forums was allocated 20% of the final grade. The remaining 80% was divided between a short paper, quizzes and a final essay. The weekly discussion activity comprised of 5–6 guided and facilitated discussion forums. Students were asked to choose 1 forum each week and comment briefly on the question posed by 11:00 pm on Friday. Students could only see posts by other students after posting their own comment. Students were instructed to discuss points raised by fellow students and were also provided with a detailed rubric for participation, a good design practice for promoting engagement (Garrison 2017). Although the content, learning outcomes, assessments and learning tools used were identical in S2 and S3, the two courses differed in four aspects discussed below and summarised in Table 18.

- **Cohort:** In S2, a total of 138 students saw the course to completion. Of the 138, 90 students were enrolled undergraduates the University while 48 enrolled via Open Universities Australia (OUA). In S3, of the 106 students that initially enrolled, 99 students saw it to completion. All students were enrolled undergraduates at the University.
- **Duration:** S2 ran over a period of 13-weeks whereas S3 ran over a 6-week period
- **Participation rubric:** The participation rubric in S3 included response to posts as a key criterion whereas the one in S2 did not
- **Facilitation:** Prior to commencement of the course, the tutor facilitating the discussion forums in S3 was instructed to reach out to students and be pro-active whereas, the tutor facilitating the discussion forums in S2 was not provided any instructions.

Table 18. Differences in the learning design of the course in S2 and S3

Design Differences	Semester 2 (S2)	Semester 3 (S3)
Cohort	138 students completed the course (University students = 90; OUA = 48)	99 university students completed the course
Duration	13 weeks	6 weeks
Participation Rubric	Response to post not included as a key criterion	Response to post included as a key criterion
Facilitation	No instructions given to tutor	Tutor instructed to be pro-active

7.7 Methodology

Application of the IMF is a multi-stage process comprising of four successive stages (see Jan and Vlachopoulos 2018). This study includes stages 1 to 3 of the IMF. Stage 4, which involves selective qualitative analysis, is not applied as it is not required to achieve the objective of the study. The following sub-sections describe the three stages of application of the IMF within the context of the case study.

7.7.1 Stage 1 – Preparation of data

Interaction data from the discussion activities in S2 and S3 was extracted from the LMS at the end of each week and coded into matrices in UCINET 6.0 (Borgatti, Everett, and Freeman 2002) to generate directed and weighted networks. The size of the networks is determined by the number of nodes, that is, the number of students and tutor/lecturer. The direction of a tie indicates the initiator and receiver, and the weight represents the number of interactions between each node (Wasserman and Faust 1994). For each week, specific SNA measures were calculated in UCINET 6.0, and radial network diagrams were generated in Social Network Visualizer 2.3 (Socnetv 2017). The radial diagrams are based on degree centralities of the nodes. Degree centrality is the number of ties to other nodes in the network (Wasserman and Faust 1994). Weights of the edges are taken into account when computing distances between the nodes; therefore, the closer the nodes are to each other in the network diagrams (Table 19 and Table 20 below), the shorter the distance between them (Socnetv 2017). The thickness of the lines connecting nodes in the diagrams represents the weight of the tie, that is, the number of interactions between two nodes.

7.7.2 Stage 2 – Static and temporal analysis

Static analysis refers to the analysis of cross-sectional networks. Cross-sectional networks are networks generated at a certain point in time, for instance, at the end of week 1. Temporal analysis refers to structural comparison of successive cross-sectional networks. In stage 2, preliminary conclusions are made from overall examination of the network diagrams generated in stage 1. Detailed examination of the corresponding SNA measures then confirms these conclusions. For instance, if a CoP is suspected, successive cross-sectional networks are compared to ascertain the presence of the process of legitimate peripheral participation (LPP) which is the cornerstone of a CoP. Simply stated, LLP signifies learning as students successively move from the periphery towards the centre of the community as experts (tutor or lecturer) move outwards. A network that resembles a CoP would present with a clear and dynamic core-periphery structure. On the contrary, if a CoI is suspected, one would not expect to see a clear core-periphery structure and evidence of LPP and instead would see a more equally distributed network. Therefore, to confirm preliminary conclusions, further in-depth analysis was undertaken.

7.7.3 Stage 3 – Aggregate analysis

Aggregate analysis refers to the examination of the cumulative network of all the interactions over the entire duration of the course. The aggregate analysis includes cumulative SNA measures as well as cumulative radial network diagrams from S2 and S3. The cumulative networks as a stand-alone do not reveal temporal structural dynamics of community formation and evolution; however, they present an overall snapshot of the structure of the community formed, if any, under the influence of the learning design. As such, analysis of the cumulative networks was used for confirmation or rejection of the conclusions drawn in stage 2.

7.8 Findings

As stated earlier, the IMF needs to be adapted and interpreted based on the context of the investigation. Therefore, before presenting findings from the study, it is imperative to explain the adaptation required to the context. In this study, the design of the discussion activities in both S2 and S3 was such that one would not expect to see deeply nested threads within the weekly

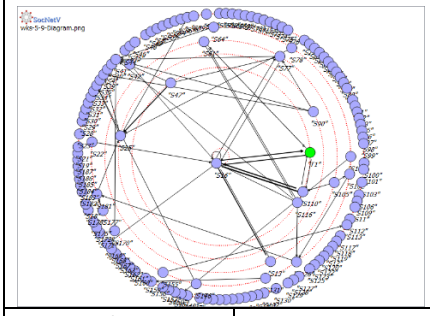
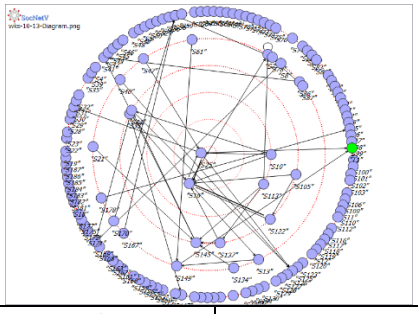
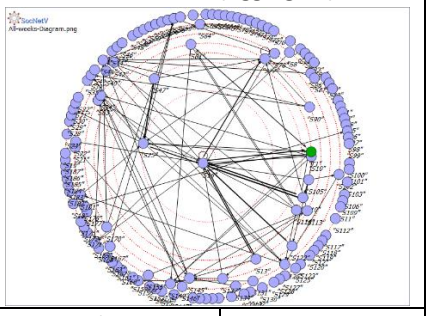
discussion networks as students were required to select only 1 out of 4–6 discussion forums each week. So, two very active students who choose two different forums in a week might not be connected directly or indirectly to one another unless another student or the tutor engages across two different forums within that week. Therefore, it would not be a surprise if the weekly networks appear clunky or disconnected and show low reciprocity (mutual exchange) and transitivity (e.g. if A->B, B->C then C->A). Based on the view that connections formed amongst participants are non-transient paths that represent potential for information flow, for the sake of brevity, cross-sectional networks comprising of a number of weeks of discussion activity are used in the investigation. Also, since the goal here is to identify the type of community formed at certain points in S2 and S3 and at the end of the semesters, the analysis is restricted to successive cross-sectional networks as opposed to successive cumulative cross-sectional networks. If the objective was to explore community evolution over time, successive cumulative networks would need to be examined. Having set the stage for the forthcoming analysis, detailed examination of the interactional data obtained from the discussion activities in S2 and S3 follows.

7.8.1 Session 2 (S2)

Table 19 shows successive cross-sectional networks from S2 over a 9-week period, that is, from week 5 to week 13 (stage 1). The networks consist of 139 nodes (138 students,1 tutor). All weeks included a discussion activity except for week 6; therefore, there were a total of 8 discussion activities (4–6 discussion forums within each). Note that discussion activities from week 1 to week 4 were not included in the analysis because of inconsistency in the size of the networks since the end of week 4 was the cut-off for dropping out of the course. Since there were a number of drop-outs, to avoid irregularity, discussion networks prior to week 4 were excluded. In the network diagrams in Table 19, students who did not engage in the discussion activities, that is, students who did not post to the discussion forums at all and students who did not either receive a response to their post or respond to another post appear as isolates on the extreme periphery. The tutor is represented by the node in green.

Overall examination of the network diagrams in Table 19 (stage 2) shows that a small percentage of students engaged in the discussion activities. This is indicated by the large number of isolates on the periphery of the weeks 5–9 and weeks 10–13 networks. In weeks 5–9, the tutor is placed between the centre and periphery of the network indicating his or her higher level of activity

Table 19. Cross-sectional networks over 8 weeks (S2)

Weeks 5 - 9		Weeks 10 - 13		Weeks 5 – 13 (Aggregate)	
					
Average degree	0.37	Average degree	0.30	Average degree	0.67
Centralization	0.47%	Centralization	0.25%	Centralization	1.53%
Components (n>1)	4	Components (n>1)	3	Components (n>1)	3
Nodes in largest component	25, T1	Nodes in largest component	26, T1	Nodes in largest component	41, T1
Cliques (n=3)	3	Cliques (n=3)	3	Cliques (n=3)	13
Core nodes	S110,S16,T1	Core nodes	S122,S16,S25	Core nodes	S110.S16,T1
Reciprocity	19.4%	Reciprocity	5.4%	Reciprocity	12.9%
Transitivity	12.3%	Transitivity	9.8%	Transitivity	11.8%

as compared to majority of the students; however, in weeks 10–13, the tutor moves out to the periphery indicating a lack of engagement. Both networks visually appear low density and with an unequal distribution of ties. Judging by the network diagrams alone, based on the IMF, the networks do not show a resemblance to a CoI. Therefore, visual inspection of the two successive cross-sectional networks does not indicate the formation of a CoI between weeks 5–9 and weeks 10–13.

Further analysis using the corresponding SNA measures in Table 19 confirms the preliminary conclusion of an unidentified community in both cross-sectional networks. In weeks 5–9, 109 (79%) of the 138 students posted to the discussion forums; however, only 31 (22%) engaged in the discussion forums within 4 components. In weeks 10–13, 95 (69%) posted to the forums and 32 (23%) engaged in the discussion forums within 3 components. Therefore, a small percentage of students participated in the discussion activities due to which both networks have a significantly low average degree of less than 1. Both networks have only 3 cliques which indicates close connections (repeated interactions) between a small number nodes (students and/or tutor) while the remaining nodes are loosely connected. In both networks, there are only three prominent nodes, the core nodes. The networks do not depict a core-periphery structure which is re-affirmed by the low centralisation of both networks. The relatively high reciprocity (19.4%) in weeks 5–9 is indicative of the mutual exchange between the core nodes. The reciprocity drops

to 5.4% in weeks 10–13, possibly due to reduced engagement of the tutor. The low transitivity of both networks re-affirms the weak connections within the networks. The low density, unequal distribution of ties, small number of cliques, a low degree of mutual exchange and low transitivity lead to the conclusion that neither network resembles a CoI. Therefore, the static and temporal analysis of the cross-sectional networks confirms the earlier conclusion of unidentified communities.

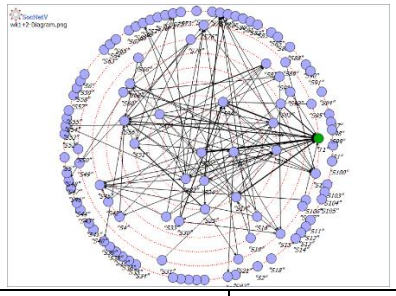
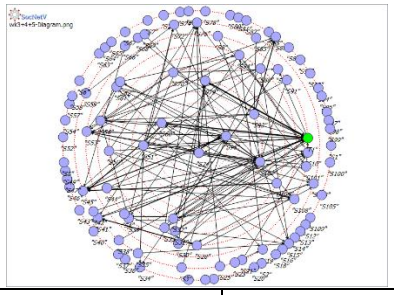
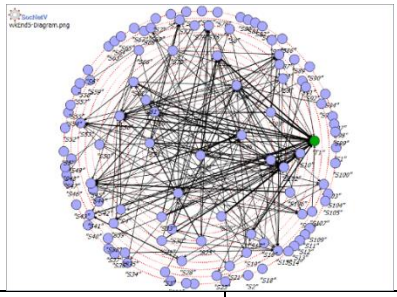
Finally, the aggregated network (stage 3) and corresponding SNA measure shows that from weeks 5–13, only 45 (33%) of the students engaged in the discussion forums within 3 components. The tutor is placed inwards due to relatively high activity in weeks 5–9. The average density, centralisation and number of cliques remain low. The core still contains only 3 nodes of which one is the tutor. The overall low reciprocity and transitivity again testify to the weak connections in the network. In conclusion, the structure of the aggregate network also does not bear resemblance to the structural characteristics of a CoI; therefore, the overall community formed cannot be classified as a CoI.

7.8.2 Session 3 (S3)

Table 20 shows successive cross-sectional networks over a 6-week period in S3 (stage 1). The weeks 1–2 network consists of 107 nodes (106 students, 1 tutor). The weeks 3–5 network comprises of 100 nodes (99 students, 1 tutor) since in week 3, 9 students dropped out of the course while 2 new students joined the course. Each week consisted of 2 discussion activities (4–6 discussion forums within each) with the exception of week 3 which had 1 discussion activity only and the final week, that is, week 6 in which there was no discussion activity. Therefore, there were a total of 9 discussion activities: weeks 1–2 (4 discussion activities) and weeks 3–5 (5 discussion activities). Again, the tutor is represented by the green node in the network diagrams. Same as in the networks from S2, the nodes on the extreme periphery represent isolates, that is, students who either did not post to the discussion forums at all or did not receive or post a response to others.

Overall examination of the network diagrams of the successive weeks 1–3 and weeks 3–5 networks in Table 20 (stage 2) shows engaged and active networks even though there a sizeable number of isolates on the peripheries. The tutor appears to be active in both networks; however, he or she is placed towards the periphery which implies repeated interactions with

Table 20. Cross-sectional networks over 5-weeks (S3)

Weeks 1 - 2		Weeks 3 - 5		Weeks 1- 5 (Aggregate)	
					
Avg. wtd. degree	1.11	Avg. wtd. degree	1.42	Avg. wtd. degree	2.38
Centralization	1.80%	Centralization	4.01%	Centralization	4.23%
Components (n>1)	1	Components (n>1)	1	Components (n>1)	1
Nodes in largest component	46, T1	Nodes in largest component	52, T1	Nodes in largest component	61, T1
Cliques (n=3)	18	Cliques (n=3)	25	Cliques (n=3)	86
Core nodes	S20,T1	Core nodes	S10,S102,S24,S32,S45,S53,S56,S60,S62,S84,S93,S96,T1	Core nodes	S10,S101,S102,S24,S32,S45,S51,S53,S56,S60,S62,S84,S96,T1
Reciprocity	2.1%	Reciprocity	8.7%	Reciprocity	6.9%
Transitivity	10.7%	Transitivity	12.3%	Transitivity	17.7%

certain students only. Within the active nodes, the networks appear dense with a reasonably equal distribution of connections. Furthermore, the networks show low degree of centralisation, and there is no visible core-periphery structure. Therefore, judging by the network diagrams alone, according to the IMF, both successive networks structurally resemble a CoI.

Further analysis using the corresponding SNA measures in Table 20 confirms the preliminary conclusion of a CoI in both cross-sectional networks. In weeks 1–2, 89 (84%) of the 106 students posted to the discussion forums; however, as indicated by the size of the component, only 46 (43%) engaged in the discussions. In weeks 3–5, 81 (82%) of the 99 students posted to the discussion forums, and 52 (53%) engaged in the discussions. Regardless of the proportion of engaged students, the average degree of both networks is greater than 1 indicating a sizeable level of interactions. Even though the centralisation of the networks increases from 1.80% to 4.01%, it remains low. There are only 2 nodes in the core in weeks 1–2, one of which is the tutor. The weeks 3–5 network has a large core consisting of 13 nodes including the tutor again. Both networks have a considerable number of cliques, which indicates tightly-knit groups maximally connected to one another. The number of cliques increases from 18 to 25 between the two

networks indicating stronger ties over time. The weeks 1–2 network has very low reciprocity (2.1%) meaning students and tutor are not responding to one another. The reciprocity increases to (8.7%) in weeks 3–5 indicating greater mutual exchange; however, it is still low. In line with the number of cliques, the transitivity increases from one network to the other but remains on the lower side meaning the networks are restrictive in terms of information flow. The low reciprocity and transitivity are a feature of the design of the discussion activity. Considering the reasonable average degree, low centralisation, equal distribution of connections, high number of cliques and evidence of mutual exchange, the static and cross-sectional analysis structurally identifies both cross-sectional networks as CoIs.

Finally, the aggregate network (stage 3) comprises of 109 nodes (108 students, 1 tutor) since it includes all students from the beginning to the end of the course. Overall, a total of 90 (83%) students posted to the discussion forums of which 61 (56%) engaged in the discussion activities as per the size of the one large component. The network has low centralisation and a large core indicating fairly equal distribution of connections. There is no evidence of a core-periphery structure. The large number of cliques represents tightly-knit groups. As expected, the reciprocity and transitivity are low. Considering the high average degree, equal distribution of connections, low centralisation, large number of cliques and presence of some mutual exchange, based on parameters in the IMF, the aggregate analysis confirms the structural presence of an overall CoI at the end of the course.

7.9 Discussion

The key objective of this article was to assess the effectiveness of the IMF in structurally exploring the formation of and identifying online CoIs. The IMF was applied to the discussion activities of two successive offerings of an online course with slight variations in the design in each offering. It was found that in S2, participants did not come together to form the structure of a CoI either during or at the end of the course. However, in S3, a CoI was structurally identified during as well as at the end of the course. The disparity in findings from S2 and S3 can presumably but not exclusively be attributed to design differences in the two offerings. The key differences in the design of the S2 and S3 course included the cohort, facilitation technique, rubric and duration. Although the impact of each of these differences cannot be isolated, the case study corroborates findings from previous research reporting the impact of time (Akyol, Vaughan, and Garrison

2011), rubric (Swan et al. 2007) and facilitation (Garrison 2017) on the development of a CoI. An additional factor contributing to the differences could be that the cohort in S2 included OUA students, whereas the cohort in S3 included university students only. The assumption being that the OUA students might not be as invested in engaging online as university students enrolled in a programme. At this point, further investigation needs to be conducted to verify this assumption. Regardless, the case study validates the IMF as an effective and valuable methodological framework for structurally exploring and identifying a CoI without needing extensive qualitative analysis. The findings verify the IMF's capability to capture and reflect variations in learning design, thereby allowing for ongoing evaluation of a CoI for assessment, diagnostics and intervention purposes.

Given the potential of the IMF, the framework promises useful practical applications for online learning designers, researchers and practitioners. The IMF can be used for retrospective as well as ongoing evaluation of a course of study. For instance, if a lecturer intends to engage students in a CoI, examination of a cross-sectional network during the course using the IMF would indicate if, in-fact, a CoI is being formed. If a CoI structure is not observed, intervention can be planned to alter the structure by, for example, adjusting the facilitation technique. The IMF can also be used to identify key participants or groups in large networks for selective qualitative analysis. Additionally, the radial network diagrams provide an effective visual illustration of participation and engagement which can be shared with students and tutors for feedback.

Coding of interactional data into matrices to create networks can be a fairly time-consuming task, especially for large networks that can be seen as a limitation. However, automation of the IMF would take care of this limitation and is under consideration. Also, although the case study highlights that different learning designs lead to different network structures which might or might not resemble a community, it does not consider other critical factors that might be contributing to online engagement and consequently community formation, for instance, individual student attributes like goal orientation and self-efficacy. Furthermore, considering the scope of the study, selective qualitative analysis of the discussion transcripts was not undertaken. To further validate the IMF, qualitative analysis of the communication between key participants is required to verify the presence of CP and TP along with the underlying SP. To date, the IMF has been effectively used to assess community formation in Jan and Vlachopoulos (2018a) [Chapter

5], Jan and Vlachopoulos (2018b) [Chapter 6], and Vlachopoulos, Matos, and Koutsogiannis (under review). Further validation is underway in ongoing research.

In conclusion, the IMF proves to be effective in assessing and evaluating learning designs intended to engage students in communities of learning. As such, the framework is considered as an advancement in social learning analytics techniques and methodologies. Researchers of online learning are encouraged to use the IMF and contribute towards its validation and refinement going forward.

8. Conclusion

8.1 Overview

The meteoric growth in online learning across the globe in the past decade or so accompanied with the availability of extensive online data from LMSs has seen a corresponding rise in research on pedagogical practices within learning communities such as CoPs and CoIs (Jan, Vlachopoulos, & Parsell, 2019 [Chapter 3]; Jan, 2019 [Chapter 4]). Historically, research on learning communities has been pre-dominantly qualitative, that is, focused on the non-structural or qualitative aspects of the communities (see Chapter 1, p. 16). Therefore, to date, there is a dearth of literature on and understanding of the underlying structure of CoPs and CoIs since a complete and holistic understanding of learning communities requires recognition and comprehension of both qualitative and structural aspects of the communities. For instance, in a CoP, we know that experts form the core of the community making a higher contribution towards reifications and production of material and conceptual artefacts as compared to novices on the periphery. However, what about the position, placement or role of these experts within the CoP in terms of, for instance, who they are connected to or are communicating with and what pedagogical implications this might have? Similarly, in a CoI, we know that intermingling of the three presences is required for a meaningful learning experience however, what can we say about the position or role of a facilitator in the community? In-fact, Wenger (1998) and Garrison, Anderson, and Archer (2000) themselves have not delved into the structural dynamics and implications thereof within CoPs and CoIs (see Chapter 2, pp. 43-47).

Given the widely held perception and understanding of learning communities from a non-structural, qualitative perspective, researchers of HEOL have also relied heavily on qualitative methodologies such as discourse (Van Dijk, 1995) and content analysis (De Wever, Schellens, Valcke, & Van Keer, 2006) of transcripts of online interactions, and survey and interview data to investigate CoPs and CoIs. As mentioned at several points in this thesis, by virtue of being time-consuming among other things, qualitative methodologies do not allow active research and thereby negate the affordances of factual, real-time online data from LMSs. Retrospective research afforded by qualitative methodologies also takes away from the immediate practical value of the CoP and CoI frameworks, a short-coming identified in literature (Garrison, 2017;

Smith, Hayes, & Shea, 2017). The immediate practical value of the frameworks potentially lies in being able to assess community formation during the course of an online learning activity so as to be able to influence its' evolution via interventions in learning design including facilitation.

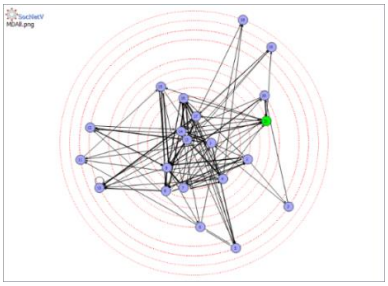
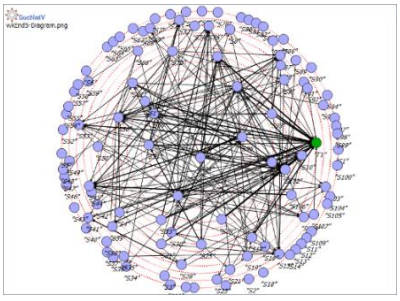
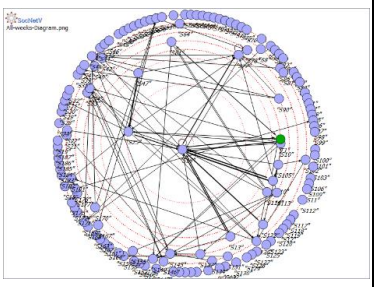
Having said that, existing literature is not devoid of inquiries on the structural aspects of learning communities which have been explored using techniques such as SNA. The well-established and intricate relationship between networks and communities discussed in Chapter 3 (Jan, Vlachopoulos, & Parsell, 2019) makes SNA an ideal choice for evaluating social learning processes within communities underpinned by interactional networks. Researchers of online CoPs and CoIs have also attempted to unravel certain structural aspects of CoPs and CoIs using SNA however, SNA constructs and visualizations have not been cultivated to their potential and SNA's application and interpretation has been inconsistent (Jan, Vlachopoulos, & Parsell, 2019 [Chapter 3]; Jan, 2019 [Chapter 4]) leading to an incomplete and murky understanding of the foundational structure of CoPs and CoIs. Furthermore, to date, reliance on qualitative methodologies persists since SNA has typically been used as a complementary technique rather than a stand-alone methodology. Therefore, research on CoPs and CoIs in HEOL remains retrospective with the applicability of findings considerably delayed. Thus, driven by the availability and affordances of data from LMSs and conviction in the potential of SNA, this research aimed to explore the structure of and structural dynamics within CoPs and CoIs using SNA as the key methodology.

This thesis began with an introductory chapter (Chapter 1) which provided the background to the research, situating it in the context of learning communities in HEOL. Following this, Chapter 2 unpacked the historical and pedagogical significance of learning communities including CoPs and CoIs to highlight the educational value of community-based learning. Going back to roots of the socio-constructivist, socio-cultural and situated learning perspectives, Chapter 2 established the role of interactions in the learning process and teased out the patterns or arrangements of interactions within CoPs and CoIs in view contextual and conceptual orientations of the CoP and CoI frameworks. Conceptualizing the communities as structurally distinct, Chapter 2 postulated that the structural differences between CoPs and CoIs would be reflected in the configuration of interactions between individuals and that these differences could potentially be detectable by SNA. This hypothesis provided the impetus to explore the use of SNA to investigate online CoPs and CoIs for which two systematic literature reviews were conducted (Jan, Vlachopoulos, & Parsell, 2019 [Chapter 3]; Jan, 2019 [Chapter 4]) where the findings of the first prompted the

undertaking of the second. Finally, findings from the literature reviews were used to develop the IMF, a framework that uses SNA as the key methodology to visually and quantitively investigate and identify CoPs and CoIs based on structural differences between them. The development, application and interpretation of the IMF was presented in Chapter 5 (Jan & Vlachopoulos, 2018). Last but certainly not least, the validity of the IMF was demonstrated in two detailed case-studies in addition to the preliminary case-study in Chapter 5. In the first case-study (Jan & Vlachopoulos, 2018 [Chapter 6]) on differently designed discussion forums within the same course, the IMF was used to identify the formation and evolution of a CoP. In the second case-study (Jan, 2018 [Chapter 7]), the IMF identified a CoI in discussion forums in two differently designed offerings of the same course.

To recap and partially illustrate the utility of the IMF in preliminary visual identification of CoPs and CoIs in HEOL, Figure 11 depicts the aggregated networks from the detailed case-studies included in this thesis. Figure 11(a) depicts a CoP from Chapter 6 (Jan & Vlachopoulos, 2018), figure 11(b), a CoI, and figure 11(c), an unidentified community from Chapter 7 (Jan, 2018). Each of the communities are based on discussion forum interactions and are formed under the influence of different learning designs. Note that the networks underlying the communities are not comparable to one another in terms of size, however, the placement of the nodes, that is, students and tutors (in green), the average degree and centralization are the distinguishing features between them among. Figure 11 illustrates the capacity of the IMF to visually and

Figure 11. Visual Identification of Learning Communities Based on Aggregate Networks

(a) Community of Practie		(b) Community of Inquiry		(c) Unidentified Community	
					
Duration of activity	9 weeks	Duration of activity	5 weeks	Duration of activity	8 weeks
No. of nodes	21	No. of nodes	100	No. of nodes	139
Average degree	6.5	Average degree	2.38	Average degree	0.67
Centralization	23.6%	Centralization	4.23%	Centralization	1.53%

holistically perform a preliminary identification of the type of community formed at the end of an online learning course comprising of interactive activities such as discussion forums. As detailed in Chapters 5, 6 and 7, to confirm the preliminary identification, specific SNA constructs need to be considered (some of which are shown in Figure 11) along with the visuals depicted. Figure 11 clearly delineates structural differences between a CoP and CoI, a perspective that has not been fully explored to date.

Recapitulating from some of the key structural components of CoPs (see Chapter 2, pp. 40-43), the configuration of connections in figure 11(a) reflects a CoP owing to the distribution of the density of the underlying network which shows a core-periphery structure, as indicated visually and confirmed by the network centralization value of 23.6% - a signature feature of a CoP. The core represents higher participation and therefore, higher reification since as per the CoP framework, participation and reification are dual processes. The higher the participation and reification, the greater the learning as reification corresponds with the creation of new meanings which are then negotiated via mutual engagement as individuals align themselves to practices of the community, in this case, the practice being learning and teaching within an online learning activity in a course of study. It is important to reiterate that figure 11(a) depicts the aggregate network only and therefore cannot be used as a stand-alone to confirm the presence of a CoP which requires temporal analysis to assess the process of LPP (i.e. a changing core periphery structure). However, the aggregate network does allow for a holistic visualization of a CoP which is the intention in the comparison presented here. As for the structural aspect of CoIs (see Chapter 2, pp. 45-47), the network in figure 11(b) is classified as a CoI by virtue of the density and distribution of interactions, again indicated visually and confirmed by the low network centralization value of 4.23%. A CoI is characterized by SP at its' core. As such, the higher the number of interactions, the higher the SP along with which TP and/or CP may or may not exist or upon which TP and/or CP may or may not develop later. Besides identifying the position of the tutor or facilitator which naturally represents TP, the IMF does not have the capacity to isolate the three presences in a CoI. However, structurally a CoI can only be present if density, that is, SP is equally distributed as it implies the potential existence of CP and TP. Therefore, unlike the case of a CoP in which learning is synonymous with participation and reification, in a CoI, based on the IMF alone, one cannot assume that SP, CP and TP intermingle with one another to create a deep learning experience. However, as stated earlier, for a CoI to potentially exist, at a

minimum, SP should be present, it should be relatively high, and it should be equally distributed, and this is what the IMF detects. The network depicted in figure in figure 11(c) is classified as an unidentified community. The visual differences between the CoP and CoI in figures 11(a) and 11(b) and the unclassified community in figure 11(c) are supported by the low network density and centralization values.

There is plenty of literature advocating the benefits of learning within CoPs and CoIs (see Chapter 2) therefore, the educational value of the communities is not at question here. The IMF was developed to fill a gap in the understanding of CoPs and CoIs from a structural perspective which has influenced research methodologies used to investigate CoPs and CoIs. Addressing this gap in understanding and research methodologies, this thesis proposes the IMF as a valid and reliable methodological framework for a structural investigation and preliminary identification of CoPs and CoIs in HEOL. The IMF is grounded in peer-reviewed and published systematic literature reviews and has been tested in multiple case-studies (also peer-reviewed and published) in different institutional and design contexts. Furthermore, having been published itself, the development, application and interpretation of the IMF has also undergone review of experts in the field. Therefore, the validity of the framework leans towards affirmation (Inglis, 2008).

8.2 Practical Implications

The key contribution of this research is development of the IMF which can be applied to online data to structurally investigate and identify CoPs and CoIs in HEOL. The IMF contributes to the field of learning communities which has been largely dominated by qualitative methodologies. Therefore, the practical implications of the research directly link with its' key contribution. The IMF provides researchers a unique structural conceptualization of the holistic and individualistic structural dynamics within CoPs and CoIs. The IMF presents as a tool that can be used by researchers as a lens for preliminary identification or potential presence of an online CoP and CoI thereby significantly reducing reliance on qualitative methodologies. For instance, in an online activity involving a large cohort of students, the IMF can be used to identify core participants or pockets of relatively high SP. The transcripts of the interactions of the core and pockets identified can then be extracted for selective qualitative analysis, if required. The IMF also enables temporal analysis of CoP and CoI formation and evolution based on the structural characteristics of the communities. The temporal analysis is conducted by examining snap-shots or time-slices of interactional networks during an online activity. Qualitative methodologies do not allow for such

an exploration by virtue of the time and effort required. In a similar vein, the IMF provides a means of conducting active research during online activities. For researchers looking to explore the impact of learning designs including facilitation techniques as was done in the case-studies in Chapter 6 and 7, this is a significant shift in research approach and understanding of CoPs and CoIs. To the best of the researchers' knowledge, to date, a framework such as the IMF does not exist therefore, the IMF fills a glaring gap in existing literature by providing researchers with a unique methodology, perspective, and understanding of CoPs and CoIs in HEOL.

8.3 Limitations of the Research

This research needs to be considered in light of its' limitations. Firstly, as it is, the IMF is only usable by researchers who are familiar with SNA. Having said that, the visualizations produced by researchers can be interpreted by academics, practitioners and even students who can use the visualizations as a basis for discussions around online engagement. Secondly, preparing data for SNA software can potentially be fairly time consuming depending on the size of the networks. Thirdly, prior to undertaking research using the IMF, ethical considerations associated with SNA need to be considered as detailed in Chapter 5 (Jan & Vlachopoulos, 2018). Fourthly, the IMF was developed based on the pre-established efficacy of learning within CoPs and CoIs, therefore, the IMF does not claim that for instance, a core participant of a CoP learns or performs better than a peripheral participant. Neither does the IMF claim that learning within a type of community is better than another, or even that learning within communities is better than otherwise. Therefore, as a stand-alone, the IMF should not be used to associate student performance with position or placement in a CoP and CoI. Lastly, further validation of the IMF is yet to be conducted by performing selective qualitative analysis, for instance, in the case-study in Chapter 7 (Jan, 2018), to verify the existence of the three presences in the structurally identified CoI.

8.4 Suggestions for Further Research

The IMF is a first attempt to conceptualize and understand CoPs and CoIs from a structural perspective. Therefore, to say the least, as it is presented and used in this research, the IMF merely touches the tip of the iceberg in the field of learning communities in HEOL. Further suggested study using the IMF are best grouped into three categories. First and foremost, the practical use of the IMF can be extended to academics and practitioners by automating the process of data extraction, manipulation, and interpretation. Should this be possible, the IMF can

potentially be embedded as an analytics tool within LMSs which can then be used on an ongoing basis to inform the design of online learning activities and impromptu intervention to influence community formation. Used in such a manner, the IMF would allow for an iterative relationship between learning design and analytics in light of CoPs and CoIs enabling cultivation of the immediate practical value of the CoP and CoI frameworks. Secondly, given that now a days universities are increasingly using analytics to assess such things as student engagement especially in the context of online learning, adding attributional data (e.g. demographics, socioeconomic status (SES), performance, etc.) to nodes representing students in the networks could provide useful insights for targeting active intervention. For instance, if performance is included as an attribute of a student and if it is found that a group of high achieving students form the core of an identified CoP, a facilitator could intervene to break the core to encourage engagement between high and low achievers. Similarly, low-achieving students who appear as peripherals in the community could be identified as those who might be at-risk and require intervention. The third suggestion for further research would be to use the IMF and test it in further case-studies so that the framework can be refined and developed further to possibly include additional SNA constructs that correspond with the structural components of CoPs and CoIs.

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10. Appendices

10.1 Appendix A. Summary of Selected Studies

ID	Author(s) Year	Title	Theoretical Framework	Methodology	Context / Participants	Key Findings
S1	Shea & Bidjerano (2010)	A re-examination of the community of inquiry framework: Social network and content analysis	Community of inquiry (CP, SP, TP)	Content analysis SNA	Online learning 2 business mgmt. courses Discussion forum n = not stated	High tutor TP and SP associated with higher levels of student SP. Within CP, triggering and reflection more common than integration. Centrality not a good indicator of CP. Measures of density align well with SP.
S2	Annese & Traetta (2012)	Distributed participation in blended learning communities: Actors, contexts, and groups	Community of practice	Discussion analysis SNA	Blended learning 3 courses in 3 academic years Online and off-line discussion forums n = 10, 15 and 23.	Online participation more cohesive before action than off-line. After re-organization, online and off-line local discussions are cohesive but not global discussions. Online discussion still more cohesive. Global cohesion increases with time. Centrality is associated with formal roles.
S3	Jimoyiannis, Tsiotakis, & Roussinos (2012)	Blogs in higher education: Analysing students' participation and presence in a community of blogging	Community of inquiry (CP, SP, TP)	Content analysis SNA Log-data analysis	Blended learning University course Blogs n = 48	Integration of ideas and construction of meaning is directly inferred from students' participation. Blogs can be implemented effectively, within a blended approach, to support students' collaborative learning. High participation indicative of CP.
S4	Shea et al. (2013)	Online learner self-regulation: Learning presence viewed through quantitative content- and social network analysis	Community of inquiry (LP)	Content analysis SNA	Blended learning Doctoral level course Journals and Discussion forum n = 18	Insignificant differences in LP, prestige and influence of facilitators and non-facilitators. Students engaged in more reflection in the journals. In discussion, LP showed moderate correlation with prestige and large correlation with influence. Journal LP, prestige and influence were unrelated.

ID	Author(s) Year	Title	Theoretical Framework(s)	Methodology	Context / Participants	Key Findings
S5	Shea et al. (2014)	Re-conceptualizing the community of inquiry framework: An exploratory analysis	Community of Inquiry (LP, CP, TP, SP)	Content analysis SNA Correlations Wilicoxon-Mann-Whitney Test	Blended learning Doctoral level course Discussion forum n = 18	TP did not play a significant role in the discussions. CP and SP showed the highest level of correlation followed by CP and LP and SP and LP. Students with high CP, SP and LP had high centrality. Significant correlation between centrality and LP and centrality and SP.
S6	Tirado, Hernando, & Aguaded (2015)	The effect of centralization and cohesion on the social construction of knowledge in discussion forums	Community of inquiry (SP, CP)	Content analysis SNA Structured equation modelling	Blended learning Graduate course Discussion forum n = 73	Network cohesion and centralization correlate positively and impact SP and CP positively as well.
S7	Wicks et al. (2015)	An evaluation of low versus high collaboration in online learning	Community of inquiry (LP)	Content analysis SNA Correlations Wilicoxon-Mann-Whitney Test	Online learning Graduate course Blogs, Discussion forum, CoI survey n = 47	Student performance not impacted by low or high collaboration. Perceived TP higher than SP in both groups. Monitoring and strategy most prominent LP components. LP correlated positively with prestige and negatively with influence.
S8	Jimoyiannis & Tsiotakis (2017)	Beyond students' perceptions: investigating learning presence in an educational blogging community	Community of inquiry (CP, TP, SP)	Content analysis SNA Log-data analysis Blogging maps	Blended learning Undergraduate course Blogs n = not stated	Decentralized learning community which evolved due to student initiatives rather than efforts of the tutor.

ID	Author(s) Year	Title	Theoretical Framework	Methodology	Context / Participants	Key Findings
S9	Jo, Park & Lee (2017)	Three interaction patterns on asynchronous online discussion behaviours: A methodological comparison	Community of inquiry (CP)	Content analysis SNA Log-data Analysis Multiple Regressions	Blended learning University level course Discussion forum n = 43	Visits on board and student centralities were predictive of achievement. Methodologies combine well for evaluation as each has its strengths and weaknesses.
S10	Satar & Akcan (2018)	Pre-service EFL teachers' online participation, interaction, and social presence	Community of Inquiry (SP)	Content Analysis SNA Log-data analysis Wilcoxon Signed Rank Test Spearman Rho's Correlation	Online learning Undergraduate course Discussion forum n = 37 and 20	Significant relationships between all SNA measures and interactive indicators of SP in the fall semester but not in the spring semester. Findings were inconclusive.

Appendix A. Summary of Selected Studies (cont'd)

10.2 Appendix B. SNA Measures, CoP & CoI Theoretical Components, and Complimentary Techniques

No.	SNA Measures	CoP & CoI Theoretical Components	Complementary Techniques
S1	Density In-degree Centrality Out-degree Centrality	Indicator of SP. Indicator of influence linked to CP, TP, SP. Indicator of prestige linked to CP, TP, SP.	Content Analysis (CP, TP, SP)
S2	Density and Cohesion Cliques Degree Centrality	Participation trajectory of whole community. Number of cliques indicator of community development. Structure of cliques impact individual trajectories. Interaction within and across cliques representative of overlapping CoP. Linked to local versus global interactions and sense of belonging within and across groups. Indicator of individual trajectories and social power. Negotiation of status and roles within community.	Content Analysis (to identify addressee) General Analysis of Discussions (excerpt provided)
S3	Cohesion Cliques Degree Centrality	Sharing ideas and beliefs linked to creation of knowledge Community architecture. Clique members as drivers of knowledge creation process. Number of cliques indicates degree of interaction and determines scope of communication Power linked to spreading information and influencing others. Identification of lurkers	Content Analysis (CP, TP, SP) Log Data Analysis for each group to identify prominent groups for SNA and CA
S4	In-degree Centrality Out-degree Centrality	Indicator of influence linked to LP. Indicator of prestige linked to LP.	Content Analysis (LP)
S5	In-degree Centrality Out-degree Centrality	Indicator of influence linked to LP, CP, SP, TP. Indicator of prestige linked to LP, CP, SP, TP.	Content Analysis (CP, TP SP, LP) Wilcoxon-Mann-Whitney Test Spearman Rho's Correlation
S6	Density and Cohesion Centralization	Indicator of rate of participation. Global cohesion as an indicator of degree centralization. Measurement of collective communication.	Content Analysis (SP, CP) Structured Equation Modelling (SEM)
S7	In-degree Centrality Out-degree Centrality	Indicator of influence linked to LP. Indicator of prestige linked to LP.	Content Analysis (LP) CoI survey Pre-test and post-test Correlational Analysis

			Wilcoxon-Mann-Whitney Test
S8	Cohesion	Sharing ideas and beliefs linked to creation of knowledge	Content Analysis (CP, TP, SP)
	Cliques	Community architecture. Clique members as drivers of knowledge creation process. Number of cliques indicates degree of interaction and determines scope of communication. Conducted on whole network.	Blogging Maps Log Data Analysis
	Degree Centrality	Power linked to spreading information and influencing others. Identification of lurkers.	
	Hierarchical Clustering	Identification of similar nodes.	
S9	Density Degree Centrality In-Degree Centrality Out-Degree Centrality	Indicator of participation rate over time. Assessment of whole network centralization. Used for regression analysis.	Content Analysis (CP) Log Data Analysis Multiple Regression Analysis
S10	Density Centralization Components Connectedness Fragmentation Average distance Diameter Compactness In-Degree Centrality Out-Degree Centrality	Indicators of SP	Content Analysis (SP) Log Data Analysis Wilcoxon Signed Rank Test Spearman Rho's Correlation

Appendix B. SNA Measures, CoP & CoI Theoretical Components, and Complimentary Techniques