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Complexity Theory and Interprofessional Education in Health

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COMPLEXITY THEORY AND INTERPROFESSIONAL EDUCATION IN HEALTH

by

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DECLARATION OF CO-ATHORSHIP/PREVIOUS PUBLICATION

I. Co-Authorship Declaration

I hereby declare that this thesis incorporates material that is result of joint research, as follows:

Chapter 4 (scoping review) is the outcome of a joint research undertaken in collaboration with my committee under the supervision of my supervisor. In Chapter 4, the key ideas, primary contributions, methodological design, and data analysis and interpretation were performed by the author and the contribution of co-authors was primarily through the provision of guidance and feedback on the methodological design, data analysis and interpretations, and manuscript writing.

I am aware of the University of Windsor Senate Policy on Authorship and I certify that I have properly acknowledged the contribution of other researchers to my thesis and have obtained written permission from each of the co-author(s) to include the above material(s) in my thesis.

I certify that, with the above qualification, this thesis, and the research to which it refers, is the product of my own work.

II. Declaration of Previous Publication

This thesis includes one original paper that has been previously published in a peer reviewed journal, as follows:

Thesis Chapter	Publication title/full citation	Publication status*
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ABSTRACT

Interprofessional education is an important means of improving health care (Barr, Koppel, Reeves, Hammick, & Freeth, 2008; Canadian Interprofessional Health Collaborative, 2010). Further, interprofessional education is becoming a recommended curricular component for gaining accreditation for many regulated health professional schools (e.g., Canadian Association of School of Nursing, Canadian Association of Occupational Therapists). Unfortunately, the evidence available to guide the design and implementation of interprofessional education is equivocal (Institute of Medicine, 2015). In an effort to improve the evidence base for interprofessional education, authors have suggested better use of theory in interprofessional education research (McMurtry, Rohse, & Kilgour, 2016; Reeves et al. 2011). Complexity theory has been identified as a useful theory to study interprofessional education (Hall, Weaver, & Grassau, 2013; McMurtry et al., 2016; Weaver, McMurtry, Conklin, Brajtman, & Hall, 2011). Complexity theory reflects how interprofessional learning is enacted in practice (Fenwick, 2012; McMurtry et al., 2016).

In an effort to understand how interprofessional learning may occur, with the goal of contributing to the evidence base supporting interprofessional education, I used two approaches to study interprofessional education using complexity theory. First, I conducted a scoping review (Arksey & O'Malley, 2005; Levac, Colquhoun, & O'Brien, 2010) to determine how researchers have used complexity theory in health services research. Interprofessional education is a subset of health services research, and I used the findings from my scoping review in combination with the findings from my literature review to inform my case study. Second, I used a multiple case study (Yin, 2013) to

explore how concepts of complexity theory—diversity and redundancy—occurred during interprofessional education with four groups of post-secondary health care students. Cases consisted of 3-5 students each and data was collected from cases using focus groups and researcher observations. Cases were comprised of interprofessional education using high-fidelity simulation. I categorized data using an apriori codebook (Crabtree and Miller, 1999) using diversity and redundancy. I then identified themes with each category using an approach described by Creswell (2007). I focused on diversity and redundancy because these concepts support aspects of complexity theory important for learning—specifically self-organization and emergence (B. Davis & Simmt, 2003).

There were 44 studies included in the scoping review—27 were qualitative, 14 were quantitative, and 3 were mixed methods. Complexity theory was most used as a conceptual framework in studies. Case studies were most common and long-term care most studied. Relationships, self-organization, and diversity were the most common concepts of complexity theory used by health services researchers. Findings from the case study research showed that diversity acted as a foundation for interprofessional learning, a foundation for interaction and a disrupter to flow. Redundancy acted as a contributor to flow and a connector within interprofessional education.

My findings demonstrate that complexity theory is being used in health services research in several ways and that it could be useful for exploring aspects of interprofessional education in health. Knowing that diversity and redundancy occur within interprofessional education in certain ways, and may support and impede interprofessional education by way of self-organization and emergence, educators may want to focus on how diversity and redundancy can be altered within groups of learners.

DEDICATION

For my parents who taught me to value discovery and education.

For Jillian, Reid, Mackenzie, and Alison—I learn from you everyday.

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TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION TO THE RESEARCH

Background

Even the simplest encounter with the health care system requires a person to interact with multiple professionals[1] who are required to collaborate effectively across diverse roles. Differences in length of training, scope of practice, employment structure, professional culture, and professional hierarchy contribute to how one might define the diverse roles of health professionals. Given such differences, what may seem like a simple encounter actually depends upon a complex and complicated orchestra of collaboration.

Interprofessional education[2] is aimed at supporting collaboration between health professionals (Canadian Interprofessional Health Collaborative, 2010). The impetus for interprofessional education is better interprofessional collaboration leading to improved outcomes for patients and work environments (Barr Koppel, Reeves, Hammick, & Freeth, 2008). Although some evidence suggests interprofessional education may result in improvements to both patient (e.g., decreased length of stay, less complications) and environmental outcomes (e.g., reduced cost of care, reduced error rates) (Reeves, Perrier, Goldman, Freeth, & Zwarenstein, 2013; World Health Organization, 2010), the literature is inconclusive (Barr, 2010; Braithwaite et al., 2007; Cox, Cuff, Brandt, Reeves, & Zierler, 2016; Institute of Medicine, 2015; Lapkin, Levett-Jones, & Gilligan, 2013; Reeves et al., 2013; Rice et al., 2010). In fact, a recent report by the Institute of Medicine (2015) noted a lack of convincing evidence for interprofessional education interventions.

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[1] In this document, the term "health professional" refers to any health care worker a person may encounter within the health care system.

[2] In this document, the term "interprofessional education" refers specifically to interprofessional education of health professionals or health professional students.

Further, comprehensive explanations for how students and/or professionals learn collectively during interprofessional education are absent in the literature. McMurtry and colleagues recently expressed concern with current interprofessional education literature: "as educators, we are dissatisfied with the interprofessional literature that treats this learning as something that is acquired by isolated individuals and transferred to other contexts" (McMurtry, Rohse, & Kilgour, 2016, p. 170). Such a statement resonates with my own experiences designing, implementing, and facilitating interprofessional education. Inconsistent evidence to support effectiveness of interprofessional education can be tolerated—it seems sensible that health care workers ought to work collaboratively and a lack of evidence does not equate to evidence of ineffectiveness (Lapkin et al., 2013). However, a lack of evidence available to guide interprofessional education is more troublesome as the logical course of action, which is often the simplified course of action, is often misguided (Fenwick, 2012; McMurtry et al., 2016).

Three related factors contribute to a lack of evidence to support specific interprofessional education interventions. They include atheoretical interprofessional education research, an underdeveloped, or early, conceptualization of interprofessional education, and an emphasis on individual learning and outcomes.

First, the weak evidence base for interprofessional education may be attributable to researchers not explicitly using theory, or more recently, relying on theory focused solely on individual learning (Fenwick 2012; McMurtry et al., 2016; Reeves et al., 2011). There are calls amongst health services researchers for increased use of theory to inform research. A lack of explicit use of theory in research exploring interprofessional education and collaboration is problematic because a lack of theory makes it difficult to

determine what elements of interprofessional education are most effective and in what contexts (Barr et al., 2005; Reeves, Lewin, Espin, & Zwarenstein, 2010). Moreover, when authors do not explicitly use theory, as has occurred in the past, tacit assumptions about interprofessional education remain unchallenged (McMurtry et al., 2016; Reeves et al., 2011). For interprofessional education, such assumptions have lead to an overreliance, albeit implied, on principles of adult learning theories (Reeves et al., 2011). An over reliance on such principles has drawn criticism for focusing solely on knowledge acquisition and behavior change at the expense of other contributing factors such as social settings and relationships (McMurtry et al., 2016).

Recently, interprofessional education researchers have begun to explicitly integrate theory into their research—a shift that some have attributed to calls from authors of reviews to do so (Reeves & Hean, 2013). Of note, despite increasing use of theory to inform interprofessional education research, organizational and systems theories (e.g., complexity theory) remain underrepresented in interprofessional education studies (Suter et al., 2013). Also notable is a recent report commissioned by the Institute of Medicine and authored by a group of international experts on interprofessional education (Institute of Medicine, 2015). Interestingly, the authors of the report did not include a recommendation of increasing theory use despite strongly advocating for improving the evidence base and research methodologies (Institute of Medicine, 2015). Despite the omission, hopefully calls for greater use of theory will continue to be made and heard, specifically theory that looks "beyond the isolated individuals and view[s] the people, social dynamics, and artifacts with which we interact not merely as backdrops to learning, but inseparable from it" (McMurtry et al., 2016, p. 170).

The second contributing factor to an underdeveloped evidence base relates to the conceptualization of interprofessional education. Authors often refer to a common definition of interprofessional education: “Interprofessional Education occurs when two or more professions learn with, from, and about each other to improve collaboration and the quality of care" (Centre for the Advancement of Interprofessional Education, 2002, para. 1). However, as Bainbridge and colleagues have suggested, the definition is largely underdeveloped at a conceptual level (Bainbridge, 2008; Bainbridge & Wood, 2013). Bainbridge focused her doctoral dissertation on answering the question: “What does learning with, from, and about other health professions mean in interprofessional health education, and how is it articulated and operationalized in the context of curriculum design?” (Bainbridge, 2008, p. 1). Using mixed methods, she offered a taxonomy of interprofessional education across different kinds of learners. Further, she concluded that there is a tendency to oversimplify what it means to help learners learn with, from, and about each other (Bainbridge, 2008). Conceptual underdevelopment of the most commonly used definition of interprofessional education, as illustrated by Bainbridge’s research, raises the question of whether the most common definition is being appropriately operationalized in existing research. Moreover, without studies informed by theory, it is difficult to know if researchers studying interprofessional education are actually studying the same concept (or concepts). Further, a committee from the Institute of Medicine (2015) substantiated Bainbridge’s claim of an underdeveloped conceptualization of interprofessional education. The committee suggested a lack of conceptual development of interprofessional education has hindered development of an evidence base:

> Having a comprehensive conceptual model provides a taxonomy and framework for discussion of the evidence linking IPE interprofessional education] with learning, health, and system outcomes. Without such a model, evaluating the impact of IPE on the health of patients and populations and on health system structure and function is difficult and perhaps impossible. (Institute of Medicine, 2015, p. 3)

The Institute of Medicine (2015) recently offered a new conceptual model of interprofessional education that encompasses patient, population, and system outcomes (as opposed to only learning outcomes). Albeit tentative, the authors offered the model as a starting point and advocated for empirical testing and adaptation. They suggested a reason for using their model is that "visualizing the entire IPE [interprofessional education] process illuminates the different environments where IPE exists" (Institute of Medicine, 2015, p. 34). Furthermore, they suggested as students enter practice:

> Learning becomes more relationship based and involves increasingly more complex interactions with others, including patients, families, and communities. While the model does not visually display the integral role these individuals and groups play, they increasingly are emerging as important members of the collaborative team. (Institute of Medicine, 2015, p. 29)

These authors are suggesting one can visualize the entire interprofessional education process and that the relationships and complexity of interactions, although important, are not captured by their model. If one conceptualizes interprofessional education as a complex system (more on this later), these two assertions by the Institute of Medicine

become immediately problematic. First, one cannot visualize a complex system in its entirety. Secondly, and more importantly, as Cilliers (2013) suggested:

> We cannot deal with reality in all its complexity. Our models have to reduce this complexity in order to generate some understanding. In the process something is obviously lost. If we have a good model, we would hope that which is left out is unimportant. (p. 35)

The complexities of relationships and interactions are very important for interprofessional education (McMurtry, 2010; McMurtry et al., 2016; Weaver, McMurtry, Conklin, Brajtman, & Hall, 2011). Omitting relationships, more specifically the intricacies of such relationships, and interactions from a model of interprofessional education, while asserting the model captures the entirety of interprofessional education, may not reflect author oversight. Instead, it may reflect the difficulty of modeling a process that is, as I will later argue, best conceptualized as a complex system. Models of complex systems will always be incomplete and often in undeterminable ways (Cilliers, 2013).

An underdeveloped conceptualization of interprofessional education has contributed to a weak evidence base for interprofessional education. Authors (Bainbridge, 2008; Bainbridge & Wood, 2013) have suggested the most commonly used definition is poorly understood. Others have highlighted the lack of conceptual clarity of interprofessional education (Institute of Medicine, 2015; Reeves et al., 2011). Despite recent attempts to develop a conceptual model of interprofessional education, the Institute of Medicine (2015) model overlooks the intricacies of relationships in interprofessional education and requires extensive testing and refinement before one can claim it captures

the essence of interprofessional education—especially if interprofessional education is conceptualized as a complex system.

The third factor contributing to an underdeveloped evidence base for interprofessional education is an overreliance on individual learning and outcomes. In a synthesis of findings from six systematic reviews on interprofessional education, Reeves and colleagues found most authors assessed outcomes at the individual learner level (Reeves et al., 2010). Although this approach may capture individual outcomes within the group, it may not fully capture interprofessional learning of the entire group. Overlooking group learning is problematic because interprofessional learning occurs within interprofessional education, often situated within complex environments, and is not achieved through isolated individual learning (World Health Organization, 2010). Recently, authors have considered focusing on the group as opposed to the individuals. In a recent review of systems and organizational theories potentially useful for interprofessional education, Suter and colleagues identified nine systems/organizational theories that have been used to inform interprofessional education (Suter et al., 2013). The impetus for their review, specifically for systems theories, was to document theories that assume organizations include purposeful interactions between system agents that behave in non-linear ways within environments. In doing so, they shifted the focus from individuals to organizations and relationships—specifically in the area of interprofessional education research and evaluation.

Recently, several authors (Fenwick, 2012; McMurtry et al., 2016) argued for more focus away from individual outcomes. For example, McMurtry illustrated that even when authors attempt to focus away from individuals and capture some group-level

interactions, specifically with the Team Observed Structured Clinical Encounter (TOSCE) tool, the evaluation remains focused only on individuals: "They are assessed as if they were the portable property of individuals. Even the 'team rating' at the end of the checklist is merely an aggregated sum of individual scores" (McMurtry et al., 2016, p. 170). Interprofessional education research should employ conceptualizations of learning (i.e., outcomes) that move beyond exploring outcomes at an individual level and then combining the results. Complexity theory offers such a perspective (Fenwick, 2012; McMurtry et al., 2016).

Problem Statement

The lack and type of theory used to inform interprofessional education research, an underdeveloped, or early, conceptualization of interprofessional education, and an emphasis on individual learning and outcomes have produced a problem in the literature and contributed to a weak evidence base for interprofessional education. As a result, there is little understanding of how best to design and implement interprofessional education. Such a problem is worthy of solutions because effective interprofessional education is an expectation of many regulatory and professional bodies (e.g., College of Nurses of Ontario, Royal College of Physicians and Surgeons), health curricula (e.g., University of Toronto Centre for Interprofessional Education, University of Alberta Health Services Education and Research Commons), and accreditation standards for health professional programs (Canadian Association of School of Nursing, Canadian Association of Occupational Therapists). Additionally, inadequate preparation of health professionals to effectively collaborate has been identified as a contributing factor for many adverse outcomes (Institute of Medicine, 2015) (e.g., The Report of the Pediatric Cardiac Surgery

Inquest Report of Twelve Deaths at the Winnipeg Health Sciences Centre in 1994). Authors are calling for a shift in how interprofessional education is viewed and studied as evidenced by large reports such as the one offered by the Institute of Medicine (2015) and publications calling for more sophisticated systems-based theoretical approaches (Fenwick, 2012; McMurtry et al., 2016; Suter et al., 2013). Authors have also suggested the use of complexity theory to inform interprofessional education research wherein the conceptualization of interprofessional education as a complex system may hold promise for improving the evidence base of interprofessional education (Arrow & Henry, 2010; Fenwick, 2012; Hall, Weaver, & Grassau, 2013; McMurtry et al., 2016).

Research Purpose and Questions

The purpose of my research is to explore interprofessional education in a health care context using attributes of complexity (specifically diversity and redundancy). Said another way, I will use the language of complexity theory for describing complex learning in interprofessional education. By doing so, I aim to extend our understanding of interprofessional education by viewing it from a complexity perspective.

My research is based on two related research questions, each with sub questions, to be answered using distinct methods:

1. How has complexity theory been incorporated in health services research?
    a. What are the characteristics of studies that use complexity theory in health services research?
    b. What settings and professions do researchers study using complexity theory?
    c. What research questions and phenomena of interest do researchers focus on when using complexity theory?

   d. How are researchers using complexity theory within health services research?
   e. How are researchers describing complexity theory within health services research?

2. How does interprofessional education occur when viewed from a complexity theory perspective?
   a. How can certain attributes of complexity theory support interprofessional education?

Format of the Dissertation

There are two formats of conventional manuscript-style dissertations. My dissertation is a hybrid of a manuscript-style and a traditional-style dissertation. The Scandinavian model consists of research papers bound as a volume and preceded by a summary chapter. The "sandwich" format consists of an introductory chapter followed by several chapters that contain the research papers in publication format and then a general discussion chapter (Gustavii, 2012). My original intent was to follow the sandwich format. Proceeding with the scoping review was not difficult. However, continuing as such with the case study findings proved impossible. Morse and Field (1995) suggested "qualitative research is best disseminated as book-length manuscripts because this gives the researcher enough space to really tell the reader what it was like" (p. 180). Of course, qualitative research is not solely disseminated in this manner, but the question of where to split the findings into manuscripts (Morse & Field, 1995) and still retain answers to my original research questions was indeterminable. Hence, I made the decision to proceed with a hybrid format, with my case study findings presented in a traditional dissertation chapter.

This first chapter serves as an introductory chapter and introduces the reader to the research problem, research questions, assumptions, significance of research, and general terminology. Additionally, I offer insight into how I came to be interested in the topic of interprofessional education.

The second chapter is a review of pertinent literature. In this chapter I review literature pertaining to interprofessional education and complexity theory. Additionally, within the review, I construct an argument for why interprofessional education can be conceptualized as a complex system and I review literature pertaining specifically to how complexity theory has been used to study interprofessional education.

The third chapter outlines the two methods used in my research. I present current literature pertaining to each method and highlight key debates in the scoping review literature. I provide a thorough overview of the interprofessional education activities that formed the cases for the case study portion of my dissertation. I also review the frameworks used to design the interprofessional activities. Likewise, I describe in detail the research designs, data collection, and data analysis strategies and provide a rationale from select literature (Crabtree & Miller, 1999; Creswell, 2007; Krueger & Casey, 2008; Morse & Field, 1995; Sandelowski, 1994; Spradley, 1980; Stake, 1995; Yin, 2012, 2013) where appropriate.

The fourth chapter is the scoping review of complexity theory in health services research that was recently published in BMC Health Services Research (Thompson, Fazio, Kustra, Patrick, & Stanley, 2016). It is in manuscript format but all references are at the end of the dissertation. To maintain consistency of my doctoral dissertation, there are slight differences between the published version and the version appearing within my

dissertation (e.g., the referencing style, the formatting style, etc.), but the essence of content is the same.

In the fifth chapter, I present my qualitative analysis in traditional dissertation format. Following Yin's (2013) suggestion, I present multiple narratives covering each of the cases as separate sections. In this chapter, I primarily follow Creswell's (2007) approach and offer quotations through the narrative analysis to give voice to participants. For observational data, I insert researcher observations to substantiate analysis.

In the sixth chapter, I present a discussion of the findings and conclude by offering recommendations for how to use the findings to support interprofessional education. I discuss limitations and implications for future research in Chapter 6.

Assumptions

I based this doctoral research on two primary assumptions. First, I made an assumption that attributes of complexity theory could be used to inform both health services research and interprofessional education research—specifically that complexity attributes would be present and detectable in the data. The assumption that complexity can be used in either form of research is based on an argument that both health services and interprofessional education are comprised of complicated and complex systems. Such an argument has been made in the literature (Cilliers, 2013; Cooper & Geyer, 2008, McMurtry, 2010; McMurtry et al., 2016; Plsek & Greenhalgh, 2001; Weaver et al., 2011); thus, it seems reasonable to suggest that if health systems and interprofessional education contain complex systems, complexity theory would be a feasible perspective for study and complexity attributes would be present and detectable.

Second, I made an assumption that if I could identify examples of how complexity attributes occur within interprofessional education, then educators could use the findings to create environments that reflect complexity attributes, and, thus, interprofessional education, from a complexity perspective. This assumption is based on the writing of Davis and colleagues (B. Davis & Simmt, 2003; B. Davis & Sumara, 2006) who proposed that complexity theory offers educators a means of identifying what is happening for the purposes of determining how it could be made to happen again.

Related to both assumptions, and locating the assumptions within the interprofessional education literature, several authors have conceptualized aspects of interprofessional education as complex systems and have subsequently used complexity theory in the design and/or study of interprofessional education. Examples include an exploration of what occurred when attributes of complexity theory were introduced to the course-planning of an undergraduate course on interprofessional education (McMurtry, 2010), an exploration of the experiences of stakeholders involved in planning an interprofessional education activity for students on placement (Weaver, et al., 2011), the design and evalaution of a series of university workshops on interprofessional education that were conceptualized and evaluated using complexity theory (Cooper & Spencer-Dawe, 2006; Cooper, Spencer-Dawe, & Mclean, 2005;), and the design and evaluation of an interprofessional learning activity for university students that was based on complexity theory (Jorm et al., 2016). In addition to empirical work, authors (Cooper, Braye, & Geyer, 2004; McMurtry, 2016; Fenwick, 2012) have offered theoretical discussions of how complexity could be used to study and inform interprofessional education.

Significance of Research

My doctoral research makes an original contribution to the complexity literature and to the interprofessional education literature. First, the findings from my scoping review lend support for how researchers have used complexity theory to inform health services research. My findings document the attributes authors have used, what settings authors have studied, and how authors have described complexity theory in their research. Although the findings stop short of suggesting how researchers should use complexity theory in health services research, I contributed to the ongoing debate of how best to use theory in health research (e.g., Fenwick, 2012; Greenhalgh, Plsek, Wilson, Fraser, & Holt, 2010; Paley & Eva, 2011) by documenting how researchers have used the theory. Furthermore, the findings from my review can be used by researchers to argue how complexity theory represents a useful perspective for studying health services phenomena—particularly those that involve relationships and change.

Second, the findings from my case study demonstrate that attributes of complexity (specifically diversity and redundancy) can be used to identify how interprofessional education may occur. On a practical level, the findings from my research will assist educators and decision makers charged with designing and implementing effective interprofessional education opportunities for health professionals. As Davis and colleagues have suggested, if we identify what is occurring from a complexity perspective within collective learning, we can work to enable those events to occur again and, therefore, support learning and education from a complexity perspective (B. Davis & Simmt, 2003; B. Davis & Sumara, 2006).

Collectively, these findings address the three factors that contribute to a lack of strong evidence supporting interprofessional education as outlined in the opening section. First, I use a theory to study interprofessional education. Most authors studying interprofessional education do not explicitly use theory, making generalizations difficult and assumptions unstated. In my research, the explicit use of complexity theory could assist authors to use the findings in other contexts and does explicate assumptions underlying the research. Second, I explicitly conceptualize interprofessional education as a complex system. In my research, interprofessional is an opportunity where students from different professions learn with, from, and about each other. However, as I will argue in Chapter 2 (literature review), the way in which they do so is akin to how a complex system operates. Likewise, as interprofessional education is a complex system, it is also nested within other systems such as health systems, educational institutions, and professional bodies. Third, I use a research methodology, case study research, and a theoretical approach, complexity theory, which shift focus away from individuals and instead capture aspects of the group within interprofessional education. Specifically, I am able to focus on a portion of interprofessional education that could not occur with only individual learning—thus, capturing the important aspects of relationships within groups that support learning.

Personal Connection to Research

I am a registered nurse with 16 years experience working in a variety of settings. In all environments, interprofessional collaboration was not easy. Despite good intentions of all health care professionals, learning and working across professional boundaries was a challenge regardless of the years of experience, work environment, or organizational

support. In the emergency department, I witnessed health professionals spending countless hours performing skills and treatments that other professionals should have done more efficiently. In northern outposts, I experienced communication breakdown during collaboration across geographical distances using technology. During a disaster relief effort in an international country, I witnessed extensive duplication of roles and scopes of practice and, thus, the misapplication of specialized skills. From these experiences, I wondered how collaboration could be improved to optimize patient care. I was not surprised to read research suggesting interprofessional education may lead to improved collaboration. I had experienced some of these findings through my encounters in clinical environments; validating my anecdotal findings with research was liberating. After several years working in clinical environments, I left clinical work to focus on nursing education, but my interest in improving collaboration remained.

As a nurse educator working in undergraduate education, I was charged with supporting learners to develop both foundational and specialized skills. Teaching in the first year of a four-year baccalaureate program, I was amazed at the perceptions of students entering the nursing program. Even though some understood how a nurse fit in the health care system, most did not consider how the other professionals collaborated with nursing to create a health care team. Although not surprising that pre-licensure nurses lacked understanding of other health care team members, it was surprising that a knowledge gap remained in post-licensure nurses. Upon reflection, it became clear that the classroom, lab, and clinical learning environments in which nurses were educated were not supporting key principles related to interprofessional education. It became apparent that introducing concepts related to interprofessional education early within

educational curricula and integrating these concepts with the other professional programs were key to the sustained success of interprofessional education. An interest in how to develop effective curricula that support interprofessional education is what motivated me to pursue doctoral education and to further explore the nature of interprofessional learning within interprofessional education.

Academically, I have studied interprofessional education and knowledge transfer within health care. During my Masters of Nursing at the University of Alberta, I studied how to increase research use in nursing. Through this work, I became interested in how different theoretical lenses could be used to explore problems and situations within health care. For example, much of the research on how to increase research use in nursing suffers from a lack of explicit use of theory (Thompson, Estabrooks, Scott-Findlay, Moore, & Wallin, 2007), which has, in turn, stunted the progression of our understanding of how to operationalize research use (Estabrooks, Thompson, Lovely, & Hoffemyer, 2006; Thompson, Moore, & Estabrooks, 2008). This, in turn, sparked my interest in how different theories can be used to study issues in health services. I was amazed at the lack of theory used to study interprofessional education and how this lack of theory was contributing to poor progression in interprofessional education research (Reeves et al., 2011).

In summary, as a registered nurse and nurse educator who has worked on and supported interprofessional teams for more than ten years, I have seen individuals and groups of health care professionals experience tremendous challenges learning with, from, and about each other. My experience with research has supported my clinical and educational experiences. Although interprofessional education can improve outcomes for

health care workers and patients, how best to design and implement interprofessional education is unknown. One approach is more use of theory when studying and designing interprofessional education. My interest in theory informed research, interprofessional education, and education of health professionals are key motivators for conducting my research.

Definition of Terms

In the following paragraphs, I provide brief definitions of key terms. Some of these terms are not easily defined in such a small section (e.g., complexity theory). A more detailed and comprehensive discussion of several of the terms is found in Chapter 2 (literature review).

Simple, complicated, and complex systems. Simple systems behave in a linear and mechanical manner (McMurtry, 2008). They have few components and the components interact in direct causal relationships (Complexity and Education, n.d.; McMurtry, 2008). Reductionist methods can be used to understand the overall system.

Complicated systems are composed of multiple components. Predictability is still possible, but prediction may rely upon mathematical techniques. Similar to simple systems, complicated systems can be understood using reductionist methods—an important factor given that it suggests both simple and complicated systems can never be "more than the sum of their parts" (Complexity and Education, n.d.; McMurtry, 2008).

Complex systems are different than simple and complicated systems. Complex systems consist of multiple components. Components within a complex system interact with the environment and other components. Interactions are not under centralized control and occur according to local rules. The outcomes of the interactions can result in

changes in the overall system and these changes can exceed the sum of the system's components. Changes in the overall system cannot be traced back to individual interactions and are not proportional to those interactions (Cilliers, 2013). One cannot understand a complex system by reducing it to individual parts (Complexity and Education, n.d.; McMurtry, 2008). For the original discussion on simple, complicated, and complex systems, see Weaver (1947). For a discussion on simple, complicated, and complex systems related to health systems, see Sturmberg and Martin (2013). A similar discussion related to education can be found in McMurtry (2008).

Complexity theory. Complexity theory is an umbrella term used to describe and explain complex systems (Cilliers, 2013). Many suggest it defies definition; thus, a discussion of complexity is provided in Chapter 2 (literature review).

Diversity. Diversity refers to the different contributions learners make to a learning collective (B. Davis & Sumara, 2006). A certain level of diversity is present in learning collectives regardless of how homogenous the group appears (B. Davis & Simmt, 2003). Diversity has many meanings that are difficult to isolate but include diverse ways of viewing and solving problems and diverse contributions to group dynamics. Diversity contributes to a systems' intelligence (McMurtry et al., 2016) and is considered to be a condition required for collective learning (Weaver et al., 2010)

Emergence. Emergence refers to the behavior of a complex system that results from interactions between components that comprise that system (Cilliers, 2013; Morowitz, 2004; Wolf-Branigin, 2013). Emergence cannot be traced back to specific interactions and the degree of emergence is not proportional to the degree of interaction (Goldstein, 1999). Likewise, emergence cannot be controlled (Cilliers, 2013). Goldstein

(1999) defined emergence as “the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems” (p. 32).

Health services research. In this research, I use the Canadian Institute of Health Research definition of health services research:

> Includes research with the goal of improving the efficiency and effectiveness of health professionals and the health care system, through changes to practice and policy. Health services research is a multidisciplinary field of scientific investigation that studies how social factors, financing systems, organizational structures and processes, health technologies, and personal behaviours affect access to health care, the quality and cost of health care, and, ultimately, Canadians' health and well-being. (Canadian Institute of Health Research, 2014, para. 6)

Interprofessional collaboration. Interprofessional collaboration occurs when multiple health care workers from different backgrounds provide comprehensive and holistic care patients, families and communities (World Health Organization, 2010).

Interprofessional education. Interprofessional education “occurs when two or more professions learn with, from, and about each other to improve collaboration and the quality of care" (Centre for the Advancement of Interprofessional Education, 2002, para. 1). Interprofessional education research is a subset of health services research.

Redundancy. Redundancy is a complementary attribute to diversity. B. Davis and Simmt (2003) suggest redundancy refers to “duplications” and “excesses” (p. 150) of contributions that are necessary for certain events to occur. Redundancy is not an impediment to effectiveness but rather a sameness that supports interaction and acts as a

stopgap (B. Davis & Simmt, 2003; B. Davis & Sumara, 2006) and is considered to be a condition required for collective learning (Weaver et al., 2011).

Self-organization. Self-organization refers specifically to the interactions that the components of a system undertake that eventually give rise to an observable change in the system. These local level changes occur without external or internal control and result in the observable appearance of a new structure or pattern at the whole system level (B. Davis, Sumara, & Luce-Kapler, 2007; Heylighen, 2001; Manson, 2001).

CHAPTER TWO: LITERATURE REVIEW

In this chapter, I present findings from a literature review to situate my dissertation in the interprofessional education literature and the complexity theory literature. My literature review is organized into two main sections. First, I present findings from a review of literature focused on interprofessional education. Specifically, I trace the history of interprofessional education, present a background on the definitions of interprofessional education, examine findings and gaps in research conducted on interprofessional education, discuss theory use in interprofessional education research. This first section concludes with an argument for why interprofessional education can be conceptualized as a complex learning system, as well as a review of the few studies that have used complexity theory to study various aspects of interprofessional education. Overall, the first section sets the foundation for why I am using complexity theory in my research. In the second section, I provide a review of the theoretical perspective guiding my research, complexity theory, with an emphasis on specific concepts of complexity theory, including self-organization, emergence, diversity, and redundancy. The findings from my literature review were combined with the findings from my scoping review to help inform my case study. Additionally, the findings from the literature review, specifically that complexity theory has been used in multiple ways to study a myriad of phenomena related to health services and interprofessional education, provides the impetus for conducting the scoping review. Of particular note, I updated the organization of my literature review following my analysis to consolidate studies by authors who used complexity theory to understand aspect of interprofessional education.

Interprofessional Education

The history of interprofessional education: Past to present. The early 1900s were an important period for interest in health care teams and teamwork (Baldwin, 2007). During the early 1900s in Great Britain and the United States, the provision of health services shifted from hospitals to communities and homes. With this shift, teams of physicians and allied health professionals (e.g., nurse, social worker, etc.) were dispatched from hospitals out into communities (Baldwin, 2007). A shift to a community-oriented team-based approach to health care benefitted many allied health professionals. For example, nurses were beginning to be viewed as "central participants who needed university-level education" (Ross-Kerr, 2014, p. 37). Baldwin identified the shift to a more team-based approach as contributing to a professionalization agenda for allied health professions as these professions sought to gain credible acceptance amongst other professions. Interestingly, a contemporary shift in more formalized university education for some professions has been identified as a barrier to interprofessional education today (Gilbert, 2005; Hall, 2005; Meleis, 2016).

Meleis (2016) identified two reasons for formalized university education acting as a barrier to interprofessional education. First, there is an inequitable distribution of power held by the medical profession, which results in members of other professions feeling less valued and having less of a voice within interprofessional education curriculum discussion (Meleis, 2016). Second, the profession-centrism promoted within universities opposes the tenets of interprofessional education. Specifically, as students learn within their professional schools, they develop a professional identity. Developing a professional identify is not a negative aspect within a professional school. However, when combined

across multiple professional schools in a university—with each school having a distinct professional identity—a culture of insiders (us) and outsiders (them) is created within the university (Meleis, 2016). Despite these current challenges, historically, it was the shift in care out of the hospital and into the community. This shift leads to a professionalization agenda and resulted in formalized university education for many health professions—which catalyzed early interest in interprofessional education and collaboration.

More recently, interest in interprofessional education for the purpose of improved interprofessional collaboration has increased over the past 30-50 years (Institute of Medicine, 2015; Reeves, Goldman, Burton, & Sawatzky-Girling, 2010). The World Health Organization has played an important role in catalyzing an organized and sustained international effort for interprofessional education. For example, an expert committee of the World Health Organization in 1973 argued traditional training programs and interprofessional education be considered complementary. From this vision came the Declaration of Alma-Ata from the World Health Organization (1978), which stated, among other items:

> Primary health care relies, at local and referral levels, on health workers, including physicians, nurses, midwives, auxiliaries and community workers as applicable, as well as traditional practitioners as needed, suitably trained socially and technically to work as a health team and to respond to the expressed health needs of the community. (VII, para. 7)

Subsequently, the Declaration of Alma-Ata led to the Health for All by 2000 movement, organized by the World Health Organization in 1978 (Oandasan & Reeves, 2005). This movement sought to expand understanding of health as being broader than the traditional

medical model and to acknowledge the social and economic factors contributing to overall health. To reach its intended goal, the World Health Organization explicitly stated a need for health professionals to learn to work collaboratively . The World Health Organization has since reported that the Health for All movement fell short of its intended goals (Chan, 2008) and has subsequently produced a report entitled The World Health Report 2008-Primary Health Care Now More Than Ever (World Health Organization, 2008). Although the 2008 report focused predominantly on primary health care, the implicit need for teams of health professionals who collaborate effectively remained a strong message from the World Health Organization.

Recently, the World Health Organization (2010) produced a report on interprofessional education entitled Framework for Action on Interprofessional Education & Collaborative Practice. The impetus for this framework arose from the shortcomings of the Health for All by 2000 movement. A reason for the original movement not succeeding was partly due to a critical worldwide health human resource shortage. As a result, the authors of the 2010 interprofessional education framework suggested that interprofessional education was a necessary solution to the shortage of health workers around the world (World Health Organization, 2010). This claim was based on the belief that interprofessional education could educate health workers to practice in interprofessional collaborations and, thereby, effectively respond to the local needs of individuals and communities (World Health Organization, 2010). Clearly, the World Health Organization has been instrumental in the history of interprofessional education.

Barr (2013) also offered a perspective on the history of interprofessional education. He identified six countries leading interprofessional education since 1960:

Australia, Canada, Japan, Sweden, United Kingdom, and United States. He distinguished the focus of interprofessional education as being either on pre-qualifying students (i.e., university or college students) or post-qualifying individuals (i.e., practising clinicians). Authors now acknowledge that targeting interprofessional education to both groups is important (Institute of Medicine, 2015). Interestingly, interprofessional education in the United Kingdom and United States evolved primarily in the area of work-based post-qualification (Barr, 2013). In other words, these two countries focused primarily on practising clinicians. A clinical focus remained until the turn of the century when both the United Kingdom and the United States shifted their focus to pre-qualifying students. Barr attributed this shift to government pressure in both countries to produce a more collaborative workforce. The other four countries focused their interprofessional education efforts primarily on pre-qualification from the outset. In a synthesis of systematic reviews on interprofessional education, Reeves and his colleagues (Reeves, Goldman, Burton, & Sawatzky-Girling, 2010) confirmed a shift from post-qualifying to pre-qualifying; however, they report that as of a 2010 review of reviews, a post-qualifying focus seems to be the predominant concern in interprofessional research.

A history of interprofessional education occurring primarily in the workplace (i.e., post-qualification) is not surprising. In a recent report commissioned by the Institute of Medicine (2015), the authors acknowledged how interprofessional education takes on a small role during early curricular activities as students form professional identities. Conversely, as students enter clinical areas to complete their education and begin practising, interprofessional education takes a more prominent position (Institute of Medicine, 2015). However, the need for interprofessional education during the formative

pre-qualifying years remains critically important. “Organized, formal interprofessional education activities provide the basic underpinnings of collaborative competence” (Institute of Medicine, 2015, p. 32).

Currently, there is renewed interest in studying interprofessional education and demonstrating that interprofessional education improves patient outcomes (Institute of Medicine, 2015). Interest stems from a focus on outcomes-based approaches to health. Despite several decades of interprofessional education research, the history of interprofessional education has not revealed consistent evidence that interprofessional education leads to improved patient outcomes (implicitly through improved collaboration) (Cox, Cuff, Brandt, Reeves, & Zierler, 2016). As such, the Institute of Medicine (2015) recently released a 183-page report based on the current evidence for interprofessional education. This report offered recommendations for how to improve the evidence-base for interprofessional education and demonstrate a causal link between interprofessional education, interprofessional collaboration, and improved patient outcomes. Briefly, the report identified alignment between educational systems and health care systems, development and adoption of a conceptual model of interprofessional education, and stronger research design and reporting as being critical aspects for showing a strong link between interprofessional education and improved patient outcomes (Cox et al., 2016; Institute of Medicine, 2015). The need for more conceptual work related to interprofessional education is of primary interest to my research. The Institute of Medicine clearly identified a lack of conceptual work as a hindrance to advancing the evidence base, of, and for, interprofessional education.

In summary, interest in interprofessional education has been traced to the 1900s with more sustained research over the past 30-50 years. Intermittent interest has produced a paucity of research demonstrating a causal link between interprofessional education and improved patient outcomes. A lack of conceptual work in the area of interprofessional education has contributed to the lack of research demonstrating the effectiveness of interprofessional education. In the next section, I review key literature on the definition of interprofessional education. I illustrate, as suggested by the Institute of Medicine (2015) and others (Reeves et al., 2011), that there are many ways to conceptualize and operationalize interprofessional education.

Defining interprofessional education in health. **T**o begin, it is useful to contrast interprofessionalism with other forms of collaborative endeavors before dissecting the terminology within the health related interprofessional education literature. First, multidisciplinary refers to drawing upon different disciplinary perspectives to solve or better understand a problem (McMurtry, 2011). In multidisciplinary work, the emphasis is simply on the "drawing upon," and, therefore, individuals working in a multidisciplinary manner, whether it is for research or practice purposes, may work independently of each other (Oandasan & Reeves, 2009). Interdisciplinary moves beyond multidisciplinary, as it aims to "integrate insights from [different disciplinary] perspectives" (McMurtry, 2011, p. 20) or "reconcile and foster cohesion" between knowledge from fragmented disciplines (D'amour & Oandasan, 2005, p. 9). Traditionally, the term interdisciplinary has been reserved for research endeavors involving multiple disciplines engaged with problems existing outside one discipline's scope of knowledge (D'amour & Oandasan, 2009). Transdisciplinarity refers specifically to the transcendent

perspective that can result from integrating insights from, or fostering cohesions between, disciplinary knowledge (McMurtry, 2011). Interprofessionalism is similar to interdisciplinary in that it refers to drawing from various professional perspectives, but the purpose is for improving collaboration among professionals (i.e., health professionals) to aid in solving problems (i.e., improving patient outcomes) (D'amour & Oandasan, 2005; McMurtry, 2011).

Moving beyond those four terms, it is also worthwhile to explicitly review terminology used within the interprofessional education literature, specifically health literature, to illustrate the varying perspectives within the field of interprofessional education research. In a review of terminology used in interprofessional education literature from 1970-2010, Paradis and Reeves (2013) noted:

> There appears to be internal divisions within health research with respect to terminology – most notably over the choice of "interprofessional" versus "interdisciplinary" or "multidisciplinary". These divisions may be the result of confusion – lack of clarity as to what is meant by each term – or of a division of research foci within the field, whereby each subfield has its own symbolic capital and speaks to a different audience. (p. 120)

Several combinations of prefixes and suffixes have been used interchangeably within the interprofessional education health literature. Authors (Bainbridge, 2008; Bainbridge & Wood, 2013; Oandasan & Reeves, 2005) recently discussed how assumptions underpinning these terms are an important area of inquiry and consideration. Overlapping of terms without careful consideration of their meaning, especially in a relatively young field of study (i.e., interprofessional education health research), can lead

to conceptual confusion and ultimately hinder research (Scott-Findlay & Pollock, 2004) and stall development in the interprofessional field (Institute of Medicine, 2015; Paradis & Reeves, 2013; Reeves et al., 2011). A discussion of terminology used in the literature follows.

To start, *profession* and *discipline* have been used interchangeably within interprofessional education literature. However, as Oandasan and Reeves (2005) suggested, there are key differences between the terms and much has been written on the differences between professions and disciplines in health care. Northrup and colleagues traced the distinction between profession and discipline in health care to the influential Flexner Report published in 1910 (Northrup et al., 2004). At the time, Flexner argued a profession differed from a discipline in that a profession was largely intellectual, learned through education, and was self-governing (Northrup et al., 2004). From this perspective, the term profession fits well in interprofessional education as almost all professions participating in current formalized interprofessional education, at least in a westernized academic context, require an educational component administered by a college or university and are registered professionals, and thus, governed by a regulatory body made up largely of members from within the profession (e.g., College of Registered Nurses of Ontario, The College of Physicians and Surgeons and Ontario, etc.). Moreover, some have argued that profession refers to a vocation that possesses its own body of specialized knowledge (Oandasan & Reeves, 2005).

Although the aforementioned characteristics of a profession came from the literature, it is helpful to examine the context from which that literature was produced. Defining profession based on the degree of education required and body of knowledge

from which it draws from is exclusionary and privileges a westernized perspective of interprofessional education and health. In many countries, including Canada, various unlicensed community members play an important role in contributing to and maintaining health (e.g., Community Health Representatives in remote communities within Canada). To capture the contribution of all members of the health care team, the World Health Organization defined professional in the context of interprofessional education as "an all-encompassing term that includes individuals with the knowledge and/or skills to contribute to the physical, mental and social well-being of a community" (World Health Organization, 2010, p. 13). Given that authors are beginning to call for more attention to terminology in the field of interprofessional education (Reeves et al., 2011), it is prudent to also acknowledge how terminology can shape, both positively and negatively, future interprofessional initiatives. For that reason, the World Health Organization's definition is both timely and visionary.

The term discipline has been used within health professions to denote areas of specialization (Oandasan & Reeves, 2009). For example, within the profession of medicine, there are several specialty areas (e.g., cardiology, dermatology, psychiatry, etc.) that are often referred to as disciplines. Therefore, within this example, the term "interdisciplinary education" would take on a different meaning—one aimed at education involving physicians from different disciplines such as family medicine and palliative medicine (Oandasan & Reeves, 2009).

Several prefixes have been used interchangeably within the interprofessional education literature. Terms such as *intra, multi*, and *inter,* are found in the literature making it unclear if author(s) intend different meanings. From a nursing perspective,

Bowers (2006) defined *intraprofessional education* as "occasions when one profession learns through collaboration from and about significant specializations to improve the quality of service" (Bowers, 2006). These specializations are found within a profession and refer to areas such as cardiology nursing, emergency nursing, and/or oncology nursing (Bowers, 2006). Bowers' definition is similar to another definition of intraprofessional education found within the medical literature: "intraprofessional education refers to education that occurs when two or more disciplines within the same profession are engaged in learning together and subsequently collaborating in the workplace" (Bainbridge & Nasmith, 2011, p. 4). Although the definition provided by the Bainbridge and Nasmith (2011) fits well within medicine or nursing, it does not fit well within other professions that are often involved in interprofessional education (e.g., social work, occupational therapy, kinesiology) where subspecialties may exist but are not as well defined by educational requirements, scopes of practice, or protected titles (e.g., The Royal College of Physicians and Surgeons of Canada). Regardless, it is possible to conclude from the literature that the term intra- is best used to refer to sub-classifications within one's profession.

Returning to the work of MacIntosh and McCormack (2001), the prefix *multi,* when used in *multiprofessional education*, describes an educational experience with less collaboration than interprofessional education. This description is aligned with the definition used in a recent report by the Royal College of Nurses in the United Kingdom (Clifton, Dale, & Bradshaw, 2006). In their report, Clifton et al. (2006) stated multiprofessional education is focused on individuals from different professions learning common content. For example, multiprofessional education could include social workers,

physiotherapists, and occupational therapists all learning about diabetes together, but not collaborating in a manner that would facilitate learning from each other or about each other's profession in the context of diabetes. So, unlike intraprofessional education, multiprofessional education includes more than one profession but lacks the collaboration required for intraprofessional education. Inferring from the literature, interprofessional education appears to be the correct term to refer to a specialized form of education that focuses on learning collaboratively with more than one profession. Likewise, a sufficient degree of interaction between learners appears critical for interprofessional education.

Although the meanings behind the terms are questionable, definitions of interprofessional education are consistent in the literature—in fact, the use of a consistent definition of interprofessional education in most research is the norm. Between 1997 and 2016, there have been countless systematic reviews conducted exploring many aspects of interprofessional education and collaboration in different contexts (Cooper, Carlisle, Gibbs, & Watkins, 2001; Cox et al., 2016; El-Awaisi, Diack, Joseph, & El Hajj, 2016; Hammick, Freeth, Koppel, Reeves, & Barr, 2007; Havyer et al., 2015; Lapkin et al., 2013; Pauzé & Reeves, 2010; Reeves et al., 2013, 2013; Zwarenstein et al., 1999) and several key commissioned reviews on interprofessional education produced (Barr et al., 2008; Clifton et al., 2006; Freeth, Hammick, Koppel, Reeves, & Barr, 2002; Institute of Medicine, 2015). Reeves and colleagues (Reeves et al., 2010) reported in a synthesis of reviews that systematic review authors often defined interprofessional education using the common definition put forward by the Centre for the Advancement of Interprofessional Education (2002): "Interprofessional Education occurs when two or more professions learn with, from, and about each other to improve collaboration and the

quality of care" (Definition section, para. 1). This finding is supported by my review of the literature wherein authors frequently cited this definition and/or source when defining interprofessional education.

Some authors have recently questioned the meaning of the most commonly used definition of interprofessional education. For example, Reeves and colleagues (Reeves et al., 2011) reported that despite sustained efforts over 30 years, very little is known about interprofessional education as a concept. Bainbridge focused her doctoral research on better understanding what it means to learn with, from, and about each other (Bainbridge, 2008; Bainbridge & Wood, 2012). In a recent publication from her doctoral work, Bainbridge suggested “learning with, from, and about each other, as articulated in the definition and even in the principles, has not been conceptualized and described fully enough to effectively inform curriculum development and evaluation of interprofessional learning” (Bainbridge & Wood, 2013, p. 453). An underdeveloped definition brings into question what authors mean when they use the definition, which is worrisome given it is the most used definition in the field (Reeves, Zwarenstein, et al., 2010). In her research, Bainbridge determined the order in which learning with, from, and about occurred was of utmost importance from a student’s perspective. Likewise, her findings offered insight into the characteristics required for learning with, from, and about. According to the undergraduate students in her study, learning about each other should precede learning from and with each other. The overall meaning of the most commonly used definition is an important consideration within a discussion of definitions. The Centre for the Advancement of Interprofessional Education (2001) definition of interprofessional education is the most used, yet, perhaps, least understood, definition in the literature. The

Institute of Medicine (2015) has recently drawn attention to how inconsistent terminology and conceptualizations have plagued the interprofessional education literature and, thereby, stunted progress.

Despite a lack of conceptual clarity within the interprofessional education literature (Institute of Medicine, 2015; Paradis & Reeves, 2013; Reeves et al., 2011), I used the term interprofessional education and the definition put forward by the Centre for the Advancement of Interprofessional Education: "Interprofessional Education occurs when two or more professions learn with, from, and about each other to improve collaboration and the quality of care" (Centre For The Advancement Of Interprofessional Education, 2002).

Empirical research on interprofessional education. Despite the purpose of interprofessional education being to improve interprofessional collaboration and ultimately patient outcomes, there is limited research suggesting interprofessional education improves patient outcomes (Institute of Medicine, 2015). For example, in a recent systematic review of the literature that combined a Cochrane Systematic review (Reeves et al., 2013) and an update (Institute of Medicine, 2015), authors concluded there were 39 studies published between 2006–2014 that met their inclusion criteria (based on study design, participants, interventions, and outcomes) and that examined the relationships between interprofessional education and either patient outcomes and/or collaborative practice outcomes (Institute of Medicine, 2015). Although 39 may seem adequate, Paradis and Reeves (2013) reported 100,488 articles were found on a recent search of PubMed for interprofessional focused research. Furthermore, the Institute of

Medicine (2015) reported methodological limitations weakened conclusions from the 39 studies.

Conversely, there is evidence to support how a lack of interprofessional collaboration (supported by interprofessional education) leads to adverse outcomes. For example, two public inquiries examining contributing factors for unexpected increases in infant mortality (i.e., more babies died than expected) in two countries offered similar results. In 1994, twelve babies died following cardiac surgery at the Winnipeg Health Sciences Centre. Between 1991 and 1995, 30-35 children undergoing heart surgery died at the Bristol Royal Infirmary in the United Kingdom. In both cases, these were higher than expected mortality rates. Although unrelated, in both cases, public inquiries were conducted and similar recommendations produced. The Winnipeg inquiry stated:

> Leadership, teamwork, communication and decision-making are recurring themes in this Report. They are not side issues, not matters of mere personality difference, but central issues. Where these issues were not resolved, they often led to tragic results. (Sinclair, 2001)

Likewise, a very similar finding was offered by the authors of the Bristol Inquiry, as cited in Thistlethwaite (2012):

> The story of the pediatric cardiac surgical service in Bristol is not an account of bad people. Nor is it an account of people who did not care, nor of people who willfully harmed patients. It is an account of people who cared greatly about human suffering, and were dedicated and well motivated. Sadly, some lacked insight and their behaviour was flawed. Many failed to communicate with each

> other, and to work together effectively for the interests of their patients. There was a lack of leadership, and of teamwork. (p. 59)

Clearly, when retrospectively examining care, teamwork and the ability of health professionals to effectively collaborate are critical. Reports such as the ones above illustrate that interprofessional education, despite a lack of firm evidence to support improvements in patient outcomes, is a necessary part of health care education.

Interprofessional education reviews. Notwithstanding the apparent need for interprofessional education and the abundance of research examining it, the literature remains inconclusive on the best way to support interprofessional education. Looking beyond research examining only effects of interprofessional education on patient or practice outcomes, several systematic reviews have been published since the 1990s (Cooper, Carlisle, Gibbs, & Watkins, 2001; Cox, Cuff, Brandt, Reeves, & Zierler, 2016; El-Awaisi, Diack, Joseph, & El Hajj, 2016; Hammick, Freeth, Koppel, Reeves, & Barr, 2007; Havyer et al., 2015; Lapkin, Levett-Jones, & Gilligan, 2013; Pauzé & Reeves, 2010; Reeves, Perrier, Goldman, Freeth, & Zwarenstein, 2013; Reeves et al., 2013; Zwarenstein et al., 1999). Reeves and colleagues (Reeves, Goldman, Burton, & Sawatzky-Girling, 2010) synthesized the findings from six systematic reviews focused on interprofessional education. The six reviews included in their synthesis were comprised of 181 studies consisting of qualitative, quantitative, and mixed methods designs. Most of these studies assessed outcomes related to changes at the learner level as opposed to the patient level. Outcomes included changes in reactions, perceptions/attitudes, and/or knowledge/skills. Findings suggested most participants valued interprofessional education with a small subset of studies suggesting that interprofessional education had a

positive impact on care. Overall, the studies included in these reviews were methodologically weak. Most authors did not describe their interprofessional education interventions in sufficient detail to permit replication or determine if reported changes were related to the intervention (Reeves, Goldman, et al., 2010). Likewise, poor sampling technique and the absence of methods to account for attrition resulted in overall poor quality. Interprofessional education interventions were most commonly delivered to post-licensure clinicians in work settings. The majority of the clinicians were nurses and doctors. The duration of education ranged from 1-2 hour sessions to several months but most lasted 1-5 days. Of note, the education often encompassed a combination of interaction, seminar based discussion, group problem solving, and role-playing. Notably, the reviews included in the Reeves et al. (2010) synthesis used broader inclusion criteria (e.g., multiple outcomes, multiple study designs, etc.) than the review previously discussed which found only 39 studies—thus explaining the discrepancy between numbers.

Returning to research focused on changes in patient or practice outcomes, a more recent Cochrane Collaboration review, Reeves and colleagues (2013) sought to determine the effectiveness of interprofessional education interventions when compared to separate, profession-specific education interventions and when compared to no education interventions. These authors explicitly examined studies that used objective or self-report measures of changes in patient outcomes (e.g., mortality rates, readmission rates) or changes in health care process outcomes (e.g., teamwork, practice style). Authors located 15 studies consisting of randomized controlled trials, controlled before and after studies, and interrupted time series designs that fit their inclusion criteria. The number of studies

included in their review suggested there was an increase in the number of randomized controlled trials, controlled before and after, and interrupted time series designs compared to their previous review that had only located six studies (Reeves et al., 2008).

The Institute of Medicine (2015) recently conducted a review to measure the impact of interprofessional education on health care delivery outcomes. They built on the results from the Cochrane review, mentioned above, and located an additional 24 studies (in addition to the 15 mentioned above). The majority of new studies were controlled before-and-after studies and the authors concluded "the number of studies that link interprofessional education with changes in practice and patient outcomes is growing. However, methodological limitations continue to confound interpretation and generalization of results" (Institute of Medicine, 2015, p. 78). The type of interprofessional activity (i.e., intervention) varied widely across studies, making it difficult to comment on how best to perform interprofessional educational. Authors reported improvements in most outcomes; however, similar to interprofessional activities, the outcomes were largely heterogeneous (e.g., teamwork competencies, communication skills, morbidity and mortality, adherence to best practices, error rates, etc.), making firm conclusions difficult. The clear conclusion from their review was that research on interprofessional education and outcomes is increasing but study designs continue to be weak (i.e., controlled before and after design).

In addition to systematic reviews, authors of a recent scoping review (Reeves et al., 2011) offered additional insight into the field of interprofessional education. The aim of their scoping review was to develop a better understanding of the interprofessional education and collaboration field and to develop an interprofessional framework. The

authors reviewed literature related to both interprofessional education and collaboration. Of the 104 studies included, the range of study designs included pre/post (n=51), post-study (n=18), randomized controlled trial (n=10), and qualitative methods (n=8). Pre/post studies also included several mixed-methods designs. Despite the expanded inclusion of study designs, several findings were aligned with the previously discussed systematic review findings. Most interprofessional education was aimed at post-licensure practitioners (n=44) as opposed to pre-licensure students (n=37), which is similar findings from systematic reviews (Reeves, Zwarenstein, et al., 2010). Pre-licensure interprofessional education primarily included seminars, workshops, simulations, and courses. Most included a classroom component and a third included a fieldwork (i.e., placement) component. The objectives of most studies were aimed at improving teamwork and communication. Measured outcomes included student reactions to interprofessional education, increased awareness, and increased knowledge. Perhaps the most striking finding was the lack of theory used to inform interprofessional research. Atheoretical research is a key finding that others have also reported (Abu-Rish et al., 2012; Clark, 2006).

There are three main flaws with the Reeves scoping review (Reeves et al., 2011). First, although they identified their study as a scoping review, they did not explicitly describe their methodology. There are several commonly cited approaches offering methodological direction for scoping reviews such as Arksey and O'Malley (2005) and Levac, Colquhoun, and O'Brien (2010). Had the authors explicitly stated the methodological approach used and cited key methodological authors, their study would be strengthened. Second, they only included Medline in their electronic database search.

Searching Medline and CINAHL is recommended for systematic reviews on nursing topics (Subirana, Solá, Garcia, Gich, & Urrútia, 2005). As interprofessional research is conducted across multiple disciplines and published in various journals (Paradis & Reeves, 2013), searching multiple databases is imperative for a scoping review pertaining to interprofessional education and collaboration. The authors acknowledged the single database search as a limitation. Third, the authors included only articles that reported on studies "that evaluated the effects of an interprofessional activity…or an activity to improve how they work together in practice" (Reeves et al., 2011, p. 168). Said another way, the authors included only studies that reported on evaluative aspects of interprofessional education or collaboration (qualitative or quantitative). This approach may have excluded a subset of studies of importance to the scoping review authors' objectives. For example, the scoping review authors aimed to examine how researchers have defined and used interprofessional education and collaboration and develop a conceptual framework for interprofessional education and collaboration. There are a growing number of phenomenological studies and theoretical articles reporting on the experiences of working in interprofessional collaborations or participating in interprofessional education (e.g., Croker, Trede, & Higgs, 2012; Hood, 2012; Mellor, Cottrell, & Moran, 2013). These study designs would be excluded from their scoping review for not being evaluative. Furthermore, McMurtry and colleagues recently advocated for a more participatory action approach to assessment of interprofessional learning (McMurtry et al., 2016)—a form of research that may not have been included in the scoping review. Notwithstanding limitations, Reeves and colleagues offered an

important contribution to the field and highlighted how interprofessional education is an underdeveloped concept.

In summary, empirical research on interprofessional education illustrates a varied picture. Authors have used many outcomes to study interprofessional education. As a result, few firm conclusions can be stated. Such a finding is not surprising given the lack of conceptual underpinnings of interprofessional education are largely underdeveloped. In the following section, I will discuss literature on a recent emphasis on outcomes within interprofessional education research.

A focus on interprofessional education outcomes. Outcome measures used to determine the effectiveness of interprofessional interventions are an important consideration when reviewing literature. As previously mentioned, heterogeneity of outcomes in individual studies creates difficulty for generalizing findings from systematic reviews. Furthermore, using a multitude of outcomes to measure the same thing (i.e., interprofessional education) presents a practical challenge for progress in the field of interprofessional education. Ideally, outcome selection should be informed by a clear conceptualization of interprofessional education (Institute of Medicine, 2015). However, as previously mentioned, despite a consistent definition of interprofessional education used across studies, a clear conceptualization is lacking. A lack of a clear conceptualization of interprofessional education has likely contributed to the heterogeneity of outcomes in the interprofessional education literature. To this end, a clear conceptualization of interprofessional education is clearly needed. Notably, since the start of my doctoral research and after my original proposal was defended, the Institute of Medicine (2015) developed a model of interprofessional education. The

authors stated the model was a starting point requiring further testing and refinement. As the academic community refines this model, the study of interprofessional education and outcomes could improve.

As part of a larger World Health Organization initiative to review interprofessional education worldwide, Thistlewaite and colleagues (Thistlethwaite, Moran, & World Health Organization Study Group on Interprofessional Education and Collaborative Practice, 2010) conducted a review of learning outcomes for interprofessional education. Their aim was to "examine how learning outcomes are articulated in the field of interprofessional education" (Thistlethwaite et al., 2010, p. 503). They searched published and unpublished (i.e., grey literature) from 1988 to 2007 and located 73 relevant papers. From this, they offered some insightful comments on the state of the science related to interprofessional education outcomes. For example, authors of studies examining interprofessional education tended to use several terms synonymously to refer to the desired outputs of their interprofessional education initiatives. These included learning objectives, competencies, capabilities, outcome-based education, and competency-based education. Thistlewaite and colleagues categorized all the outcomes reported in their review into six categorical themes: teamwork, roles/responsibilities, communication, learning/reflection, patient, and ethics/attitudes. Within each theme, they identified subthemes of outcomes (e.g., shared decision making was a subtheme of communication, teamwork including team leaders and team members). Outcomes related to teamwork were most commonly assessed followed by outcomes related to roles/responsibilities. Furthermore, learning outcomes were not defined in many studies and instead were implied by the evaluation tool used in the study.

Finally, outcomes were often assessed using self-report. Overall, assessment of interprofessional education outcomes in the literature was very broad. There were no agreed upon outcomes nor were there agreed upon methods for measuring interprofessional education (Institute of Medicine, 2015). A likely contributor to this quagmire was the lack of a clear conceptualization of interprofessional education, as one requires a clear understanding of what one is measuring.

In summary, there have been several systematic reviews and scoping reviews on the topic of interprofessional education. Empirical literature is increasing, but remains largely atheoretical, focused on post-licensure clinicians, and quantitative in nature. There are no agreed upon measurement outcomes of interprofessional education. Likewise, although the definition of interprofessional education is consistent, the conceptualization of interprofessional education is questionable. The latter point likely contributes to the lack of agreed upon outcomes and could perhaps be remedied by addressing calls for increased theory and qualitative research examining interprofessional education. In the next section, I will review the use of theory to inform interprofessional education research.

Theory in interprofessional education. Several authors have called for increased use of theory in interprofessional education research (Colyer, Jones, & Helme, 2005; McMurtry et al., 2016; Thistlethwaite et al., 2010). These calls have originated from the inconsistent evidence base for interprofessional education, which I outlined in the previous sections. A recent review (Reeves et al., 2011) found approximately 20 out of 104 studies examining interprofessional education integrated theory (Reeves et al., 2011). Such a broad approach to theory use in interprofessional education research is common.

With researchers drawing from theories from other disciplines (e.g., education, sociology, and psychology) (Hean et al., 2015), it is questionable whether the field of interprofessional education is better to borrow existing theories from other areas (e.g., education, organizational science) or to develop theory of its own.

In their edited book on interprofessional education and theory, Colyer and colleagues (Colyer et al., 2005) raised the question of borrowed theory. They argued against borrowing theories from other areas and suggested that theories developed outside an applied context may not be compatible with a new context. For example, underlying assumptions and implied relationships that exist within a uniprofessional education context may not apply within an interprofessional context. The argument for borrowing theories from other areas was articulated by Sills (2005): "some theories inform the learning, others the practice for which the learning prepares, and some both" (p. 93). Interestingly, a similar argument was made my B. Davis and Sumara (2009) in the context of theory in education. B. Davis and Sumara suggested it was problematic to import non-educational theory into educational contexts because the imported theory rarely originated from areas that encompassed the practical aspects of education. They suggested many imported theories too often were aimed at description as opposed to practice and concluded complexity theory had much to offer educational research. B. Davis and Sumara importantly locate complexity theory as a transdisciplinary educational theory—a theoretical perspective that transcends the borders of disciplines and their distinct epistemological methodologies. By locating complexity as transdisciplinary, complexity becomes less of a theory that can be borrowed from another discipline and applied within education and more of a perspective that illuminates what is already

occurring in education—among other disciplines, including those where complexity originated.

In her doctoral research, Bainbridge (2008) explored the debate between borrowing and creating theory and suggested that the complexity of interprofessional education necessitates using already existing multifaceted theories. More recently, McMurtry and colleagues (McMurtry et al., 2016) presented a similar perspective by arguing for increased use of socio-material theories to guide interprofessional education research. The impetus of McMurtry's argument, similar to B. Davis and Sumara's (2009), was that interprofessional education relies more on social and material aspects than individual aspects of learning and, therefore, any theory used to study interprofessional education should also capture these social and material aspects.

Several authors have offered frameworks and reviews of theories that may be applied to interprofessional education. In 2007, Reeves and colleagues conducted a scoping review to identify organizational and education theories relevant for interprofessional practice and education (Reeves et al., 2007). In this 60-page report, the authors summarized theories used within interprofessional education and interprofessional practice, provided a description of other theories useful to guide the design and implementation of interprofessional education and practice, and provided a description of theories to inform empirical findings from research exploring interprofessional education and practice. The Reeves review represents the most thorough review of theory in interprofessional education to date. The authors identified 34 theories that have been used in interprofessional education and practice and grouped them into six perspectives: social psychology (n=12), sociology (n=7), adult learning (n=4), systems

(n=5), psychodynamic (n=3), and organization (n=3). In a subsequent scoping review examining evaluative components of interprofessional education and collaboration, Reeves and colleagues (Reeves et al., 2011) reported that the authors of only six studies used theory. The discrepancy is likely because the previous 2007 review was not restricted to evaluative research and included a much broader inclusion criterion than the 2011 scoping review. Nonetheless, it is clear there are many theoretical perspectives to chose from within an interprofessional context, but perhaps slightly less when conducting evaluative research in the area. In addition to reviewing theoretical perspectives that have been used to guide interprofessional education research, Reeves and colleagues (2007) also searched for and reported on theories that could inform interprofessional education research but have yet to be used in such a context. They located 33 additional theories and grouped them into three categories: individual level theories (n=9), team level theories (n=13), and systems level theories (n=11). In conclusion, their work suggests that there are at least 67 possible theories to choose from within an interprofessional educational research context. Hean et al. (2009) suggested that the abundance of theoretical perspectives available to guide interprofessional education research has resulted in "each author using a favored approach to articulate his/her own understanding" (p. 250).

Hean and colleagues (Hean, Craddock, & O'Halloran, 2009) presented a narrow review of theory to guide interprofessional education. In their review, the authors focused "specifically on learning theories by which we mean those theories that describe how interprofessional education interventions are run or organized" (Hean et al., 2009, p.

251). Additionally, they structured their review based on whether a theory fit within a behaviorist or constructivist perspective of learning.

Hean and colleagues (Hean et al., 2009) defined behaviorism generally as a theoretical approach to learning that values the outcome over the process of learning. Although an observable outcome of learning is aligned with traditional behaviorist views (Martinez, 2009), Hean and colleagues made the explicit assumption that those researchers examining interprofessional education who use interprofessional competencies as outcomes are researching from a behaviorist perspective. The assumption is made because Hean et al. are equating interprofessional competencies with observable learning outcomes from a behaviorist perspective. However, researchers who are measuring competencies may not always be doing so from a behaviorist perspective. For example, when describing specific interprofessional competencies in the context of an interprofessional education framework, the Canadian Interprofessional Health Collaborative (2010) suggested that "rather than focusing on demonstrated behaviors to determine competence, the framework relies on the ability to integrate knowledge, skills, attitudes, and values in arriving at judgments" (p. 8). This description suggests some authors of interprofessional research view competencies as process and outcome—thus, the assumptions made by Hean and colleagues that competencies are compatible with a behaviorist perspective on learning are questionable.

Nonetheless, Hean and colleagues (2009) reported several authors implied a behaviorist approach to interprofessional education and noted the Kirkpatrick model of evaluation (Freeth, Hammick, Koppel, Reeves, & Barr, 2002) was the most common approach to evaluating interprofessional education. The Kirkpatrick model proposes

levels of change that should occur when students participate in interprofessional education. Changes include: student reaction to learning experience, modification of attitudes/perceptions, knowledge/skill acquisition, behavior change, organizational practice change, and client benefit. Hean and colleagues made an important point regarding the use of this model and other theoretical perspectives that rely on measuring behavior change. That is, it is very difficult to measure behavior change of interprofessional education beyond self-report.

Hean and colleagues (Hean et al., 2009) also found constructivist theoretical approaches were more common than behaviorist learning theory in the interprofessional education literature. In their review, they divided constructivism into cognitive constructivism and social constructivism. Cognitive constructivism pertains to the processes of learning experienced by individuals whereas social constructivism captures how learning is also mediated by the environment and surroundings. Clearly these definitions are more closely aligned with the notion of learning with, from, and about each other than behaviorist perspectives. The majority of theories used in interprofessional education research fell within the social constructivist category; however, Hean et al. noted an important perspective within cognitive constructivism that authors have explored was how interprofessional education may guide students through various stages of development. Specifically, Hean et al. (2009) suggested some authors have explored Perry's stages of student development. Perry (1981) argued students progress through a growth scheme consisting of four stages: dualism, multiplicity, relativism, and commitment. In dualism, students seek right or wrong answers to problems and the ultimate goal is to learn the right answer from experts. According to

Perry, this would constitute a student in the early years of a program. At the other end of the spectrum, in commitment, students accept and integrate knowledge learned from others with their own experience and reflection. Hean et al. suggest that greater application and exploration of stages of development within interprofessional education may help advance the field.

According to Hean et al. (2009), social constructivism is the group of learning theories that offers the most promise for researching interprofessional education. Interprofessional education is about learning with, from, and about each other, and, therefore, it makes sense that the learning theories capturing both the individual and the environment (including groups of people) are most closely aligned with an interprofessional education perspective. Hean et al. identified communities of practice theory and activity theory as being key theories to interprofessional education. Specifically, the authors combined the two theories to help explain how learning may occur within a group (as is the aim with interprofessional education). From this perspective, Hean and colleagues suggested learning would occur between individuals within a community "in parallel and simultaneously to people and organizations learning within the system" (p. 258). Hean et al. reported searches for communities of practice and activity theory within the interprofessional education literature were unsuccessful. This finding suggests neither theory (or combined theories) is used frequently by researchers studying interprofessional education. A lack of theory use is not surprising given the findings from other reviews suggesting that theory is rarely used to guide interprofessional education research (Colyer, Helme, & Jones, 2011; Reeves et al., 2007).

In summary, despite increased calls for theory use to guide interprofessional education research, there is limited use of theory. A lack of theory use is not attributable to a lack of theory to draw from given that multiple theories exist within various disciplines that could potentially offer a theoretical perspective to guide interprofessional education research. There is no agreed upon theory that should be used, and, at present, \ investigators working within the field of interprofessional education research are free to chose a theoretical perspective that is best aligned with their understanding of interprofessional education. Having a choice of theory is beneficial, but theory choice is difficult given a conceptualization of interprofessional education that is underdeveloped, and, despite consistency in the literature, a clear conceptualization of what it means to learn with, from, and about each other has not been fully explored.

For my research, I will use specific aspects from complexity theory to inform the study. There are many theories to chose from when researching interprofessional education and complexity theory is the theory I feel best fits with my conceptualization of learning with, from, and about each other. In the following section, I argue why complexity theory offers an appropriate fit for my research and then provide an overview the key aspects complexity theory I will use.

Interprofessional learning as a complex system. How we view something will influence what we see. At first glance, the simplicity of this statement overshadows the profound influence theoretical perspectives have had on how (or if) a field of study progresses. Of course, it makes sense how we look at something influences what we see. But what we see inherently influences how we understand what is occurring and, in the context of an activity (e.g., interprofessional education), how we support that activity. In

the previous section, I reported on results from systematic reviews and other literature that suggested, although many theories are available, the field of interprofessional education suffers from a lack of theoretically informed research. A lack of theory-informed research might suggest a lack of agreed upon theoretical direction. Contemporary researchers are able to choose, with sufficient argument and rationale, the theoretical perspective from which to guide their research. In this section, I will review literature on several concepts of my chosen theoretical perspective—complexity theory. In doing so, I will construct an argument for why concepts of complexity theory might be useful to understand interprofessional education. The premise of my argument stems from the previous section and is based on how conceptually and theoretically interprofessional education is largely underdeveloped and, as a result, existing research offers equivocal evidence on how to proceed. First, to begin my argument, I will illustrate how interprofessional education can be conceptualized as a complex learning system.

During interprofessional education, students from more than one profession are supposed to learn with, from, and about each other (Centre for the Advancement of Interprofessional Education, 2002). This definition, the most commonly cited definition in the interprofessional education literature, suggests two important conditions must occur for interprofessional education to happen. First, there must be at least two people from two professions present and engaged in interaction. Second, learning must occur in several "directions." Elaborating on the second point, if one is to learn with, from, and about someone else, it is logical those involved could be considered as doing the learning (with and about) and providing the learning (from and about). In a call to develop a theoretical framework to guide interprofessional education, Clark (2006) found most

authors assume interprofessional education "is the knowledge students learn with, from, and about each other in interdependent work groups" (p. 579). Although this statement captures both the interaction and learning required for interprofessional education to occur, it places clear emphasis on who is learning. More specifically, it suggests the individuals are the sole learners. Obviously individuals learn, however, B. Davis and Sumara (2001) offered a profound idea that a collective may also learn. They called this a *learning system* and define it as "any complex form that can adapt itself to changing circumstances" (B. Davis & Sumara, 2001, p. 88). Interprofessional education may be conceptualized as a learning system as it can adapt itself, through learning, to changing conditions. In other words, the entire interprofessional group within interprofessional education may learn through social processes (McMurtry et al., 2016) that can be considered complex. This is not the same as conceptualizing a group of learners as a group of individuals who learn together (McMurtry et al., 2016). Instead, it is akin to conceptualizing, as David and Sumara (2006) have done, learning as a group of us as opposed to a group of individuals. Conceptualizing an interprofessional-learning group as complex learning system is important if concepts of complexity theory are to be applied to better understand interprofessional education.

As outlined in the definition section, systems may be classified as simple, complicated, or complex (B. Davis & Sumara, 2001; McMurty, 2008; Stanley, 2005; Sturmberg & Martin, 2013). Simple systems usually consist of a small number of components. They are understandable using reductionist methods—you can understand how they function and predict how they perform by understanding their component parts (McMurtry, 2008). Complicated systems consist of more components than simple

systems. They are also predictable and understandable using reductionist methods (McMurtry, 2008; Sturmberg & Martin, 2013). To understand a complicated system, one can understand individual components, often using mathematical techniques, then use that understanding to predict how the system will perform. Examples of complicated systems include clocks, cars, and airplanes (B. Davis & Sumara, 2001; Sturmberg & Martin, 2013). That said, a learning system in the context of interprofessional education is not a simple or complicated system. In fact, it is impossible to reduce interprofessional education to its parts and use knowledge of those parts to predict how the system will emerge. Conversely, we cannot teach interprofessional education by trying to fill each individual with knowledge (McMurtry et al., 2016). There are simply too many factors interacting in too many ways to reduce interprofessional education to individual parts. Additionally, as others have shown, the outcomes of interprofessional education (i.e., collective learning) exceed the sum of their parts (McMurtry, 2010; Weaver et al., 2011). Interprofessional education, or a learning system in an interprofessional context, is more accurately a complex systems (Cooper et al., 2004; Cooper & Geyer, 2008; Cooper & Spencer-Dawe, 2006; Cooper et al., 2005; Fenwick, 2012; McMurtry, 2010; Weaver et al., 2011).

Complex systems are not comprised of discrete parts that are understood (or learn) in isolation from the system they originate in (Sturmberg & Martin, 2013). Instead, complex systems "transcend their components" (B. Davis & Sumara, 2001, p. 88) and are more than the sum of their parts (McMurtry, 2010; Weaver et al., 2011). This "more than" statement does not refer to a simple additive approach of analysis. Instead, "more than" refers to a qualitative aspect that is produced in a complex system when the parts

are combined (Stanley, 2005). In an interprofessional education context, adding knowledge to individuals and subsequently adding the knowledge of individuals will not produce "more" knowledge within a group (McMurtry, 2010). However, combining knowledge of the participant, and supporting them to learn with, from, and about each other through social processes will produce more than what exists when the members are in isolation (McMurtry, 2010). Additionally, as learners within a system learn, they adapt and change. Other learners within the system are unable to predict how another learner may adapt and change within the context of interprofessional education. This is a key point as learners are also expected to support learning (recall the definition of learning with, from and about each other). As such, the adaptations that learners undergo concomitantly change the learning context for the others and this occurs simultaneously with learning. According to Axelrod and Cohen (2001), when agents adapt, when their adaptations are unpredictable by other agents, and when these changes influence the context in which other agents adapt, the system is known as a complex adaptive system. Interprofessional education is clearly more aligned with a complex system than with a complicated system.

Conceptualizing interprofessional education as a complex learning system has implications for how one views and studies interprofessional education. Theories that aim to reduce interprofessional education to parts will not yield the same results as those theories that capture the wholeness of the phenomena (Hall et al., 2013; McMurtry et al., 2016; Sargeant, 2009). More specifically, if interprofessional education is a learning system that is complex, concepts of complexity theory may be useful for exploring and understanding what is occurring when students learn with, from, and about each other. In

the next section, I will review studies by authors how have used complexity theory to explore aspects of interprofessional education.

Complexity theory in interprofessional education research in health. Several authors (Cooper & Spencer-Dawe, 2006; Cooper et al., 2005; McMurtry, 2010; Jorm et al., 2016; Weaver, et al., 2011) have used complexity theory within interprofessional education research in health. This small but important body of literature can be divided into two categories: research on the experiences of educators involved with interprofessional education (McMurty, 2010; Weaver et al., 2011) and research on the design and evaluation of interprofessional education activities (Cooper & Spencer-Dawe, 2006; Cooper et al., 2005; Jorm et al., 2016). My research explores what occurs within interprofessional education from a complexity theory perspective; thus, it is useful to review the four studies in more detail.

Starting with research that explored experiences of educators, McMurtry (2010) used participatory action research to combine aspects of complexity theory into the planning of a university-level course on interprofessional education. Further, he used complexity theory to track the results of the course according to facilitators. His work is unique in that he explored how complexity theory influenced the facilitators' understanding of both interprofessional education and complexity theory within course development. McMurtry used B. Davis and Sumara's (2006) ideas related to diversity and commonality, openness and constraint, and decentralized interactions and organization. Participants in the course planning collaboratively interpreted these conditions. McMurtry offered insight into how, within interprofessional education, complexity theory offers an explanation for how collective knowledge produced within

interprofessional education can exceed the sum of its parts. More specifically, McMurtry suggested that enabling team members to "recursively elaborate on one another's idea and thereby create collective knowledge" (p. 225) is an example of how knowledge can be created that exceeds the sum of the knowledge held by individuals within the team—a point that resonated with the facilitators involved in the study. Additionally, McMurtry's findings suggested students in interprofessional education do not need to understand the cognitive maps of students from other professions to reach consensus, but instead need to consider their individual contributions as contributing to the overall knowledge of the collective. He used the notion of contributions as collective knowledge to suggest that collective knowledge emerges when students are able to coordinate their expertise within the group. Finally, expanding on the idea of trust in interprofessional education, McMurtry suggested trust is a form of redundancy that helps balance the diversity of the group. Collectively, McMurtry's findings demonstrate how the work of Davis and colleagues (B. Davis and Simmt, 2003; B. Davis and Sumara, 2006; Davis et al., 2007) can be used in interprofessional education research.

Similar to McMurtry (2010), Weaver et al. (2011) used complexity theory to explore the experiences of stakeholders involved in planning an interprofessional education activity for health students on clinical placements. Also similar to McMurtry's work, Weaver et al.'s research used attributes of complexity theory described by Davis and colleagues (B. Davis and Simmt, 2003; B. Davis and Sumara, 2006; Davis et al., 2007). Specifically, Weaver et al. conducted a retrospective analysis of focus group data, which they called a case study, using three key principles of complex systems and five conditions required for nurturing collective learning. The principles they used were

emergence, more than the sum of their parts, and nestedness. The conditions they used were diversity, redundancy, neighbouring interactions, decentralized control, and enabling constraints. Weaver et al.'s research offered examples of how principles and conditions of complexity existed within the group of stakeholders charged with planning an interprofessional education activity. All principles and conditions were found to be present in their data. Related to my research, they used attributes of complexity (principles of complex systems and conditions believe to support collective learning) to categorize data and then identify themes using approaches outlined by Crabtree and Miller (1999) and Yin (2013)[3]. Of particular interest to my research, the authors were able to offer concrete guidance from their findings. However, it is noteworthy that their research, similar to McMurtry's (2010), focused on those involved with designing interprofessional education as opposed to those participating in an activity—thus, the complex system they were studying differs from mine.

The two studies outlined above drew heavily from the work of B. Davis and Simmt (2003), B. Davis and Sumara (2006), and Davis et al., (2007)—literature that Weaver et al. credited as being the authors who first articulated such conditions in an educational context. The works of Davis and colleagues are thought to identify conditions that, according to complexity theory, are necessary for collective learning to occur. As such, further in my literature review, I will review Davis and colleagues' work in more detail. However, first, I will review the two studies I am aware of that used complexity theory to design and evaluate an interprofessional education activity.

[3] Weaver et al. (2011) used an earlier edition of Yin than I used in my research.

Cooper and colleagues (Cooper and Spencer-Dawe, 2006; Cooper et al., 2005) used complexity theory to design a large-scale interprofessional education project using two rounds of interventions and evaluation. The entire project was aimed at approximately 500 university level pre-licensure health students (physiotherapy, medicine, occupational therapy, nursing, and social work). The first intervention, identified as "phase one" and published separately (Cooper et al., 2005) from the second phase (Cooper & Spencer-Dawe, 2006), was guided by complexity theory, specifically the attributes of connectivity, diversity, self-organization, and emergence. Cooper et al. (2005) suggested complexity theory,

> highlighted the need to focus on student learning as an emergent and constructed process, the need to try different interacting approaches to learning, and to let direction arise by shifting attention towards those things that work best. It also highlighted the need to follow a multi method approach to evaluation which would allow both outcomes and processes and the web of relationships between them to be explored. (p. 494)

The intervention was aimed at supporting students to learn with and from each other for the purpose of promoting collaborative practice. The intervention included a training program for staff, e-learning materials, and team-working skills workshop for students.

Cooper et al. (2005) stated the evaluation was guided by complexity theory, but it is not immediately clear in the publication how the theory informed the intervention. Nonetheless, they used mixed-methods to evaluate their work; an approach they suggested aligned with complexity theory, and reported generally positive results. Most notably, they identified the need to create interprofessional education opportunities early

in the curriculum. During phase one, despite authors stating complexity informed the evaluation, they did not explicitly return to complexity theory to frame or discuss their results.

In phase two of their study (Cooper & Spencer-Dawe, 2006), they involved "service users" within the intervention. They defined service users as "a person who is (or has been) on the receiving end of any type of health or social care service, or who is providing care for another person(s)" (Cooper & Spencer-Dawe, 2006, p. 604). The authors stated they used a-linearity, unpredictability, self-organization, connectivity, and emergence as a foundation for their activity and evaluation. They offered several insights based on their findings and in the context of complexity. First, the involvement of the service-users provided the necessary connectivity. Second, the focus of interprofessional facilitation should account for non-linearity and unpredictability. Third, the control of interprofessional education should be distributed (i.e., decentralized control). Fourth, outcomes of interprofessional education emerged from processes of connectivity, self-organization, and emergence as opposed to "the direct results of inputs" (Cooper & Spencer-Dawe, 2006, p. 616).

Cooper and colleagues appear to be the first to apply complexity theory to an interprofessional education context within health. In addition to their empirical work, they offered a theoretical discussion of complexity theory in an interprofessional education context (Cooper et al., 2004). Some of the complexity attributes Cooper et al. (2005) and Cooper and Spencer-Dawe's (2006) used in their research are different from the attributes that McMurtry (2010) and Weaver et al., (2011) used in their research—likely due to the dates of each study. There was little overlap in the complexity theorists

cited between the research groups, supporting the idea that complexity theory is being used in multiple ways to study aspects of health (Paley, 2007; Thompson et al., 2016).

Approximately 10 years after Cooper's work (Cooper & Spencer-Dawe, 2006; Cooper et al., 2005), Jorm et al. (2016) used complexity theory to design and evaluate an interprofessional education activity for approximately 1200 university health care students. Jorm et al. drew upon Fenwick's (2012) critical analysis of complexity theory used for collaborative learning—who used McMurtry (2010) as an example of how complexity theory can be used in interprofessional education research—and Cooper's earlier theoretical work (Cooper, et al., 2004). They used three attributes of complexity theory (diversity, self-organization, and emergence) to design their interprofessional education activity. Jorm et al. used diversity and self-organization to provide opportunities for students from multiple health programs to "build on and challenge one another's ideas" (p. 3). An emphasis on "building upon ideas" is similar to what McMurtry (2010) described as emergence of collective knowledge. Simililarly, Jorm et al. used emergence as the conceptual basis for the summative student evaluation within their study. Specifically, they reported that students completed a written patient management plan and create da video illustrating their case and their collaborative approach. Jorm et al. conceptualized the management plan and video as emergent products that reflected the collective knowledge that emerged from diverse students self-organization within the activity. They surveyed students and concluded the activity was acceptable and feasible. Using qualitative analysis, they conducted an inductive thematic analysis and then compared a framework based on complexity theory to the data. The authors developed a thematic framework using complexity theory, but it appears to have

been done post-hoc analysis and it is not clear in the paper if or how complexity theory informed the qualitative data analysis. Likewise, the authors do not discuss their findings using complexity theory, but do conclude that their study provides support for applying complexity theory in designing interprofessional learning activities.

In summary, some of the findings and approaches outlined in this small, but important body of literature on complexity theory and interprofessional education, combined with the findings from my scoping review on how health services researchers have used complexity theory to inform their research, helped inform my case study. Most notably, the works of Davis and colleagues (B. Davis and Simmt, 2003; B. Davis and Sumara, 2006; Davis et al., 2007), McMurtry (2010), and Weaver et al., (2011) were influential. Cooper and colleagues (Cooper & Spencer-Dawe, 2006; Cooper et al., 2004) were not as influential to my work given the attributes of complexity theory they used, the focus of their research, and methods they employed. Likewise, Jorm et al.'s (2016) study did not influence my case study as it was published after I had completed my data analysis.

In the second section of my literature review, I will discuss complexity theory and the key concepts of complexity theory related to my research. The four concepts I focus on, based on an initial review of the complexity literature, are emergence, self-organization, diversity, and redundancy. As I will demonstrate, diversity and redundancy can support interprofessional education directly, whereas emergence and self-organization can support interprofessional education indirectly through diversity and redundancy. In other words, diversity and redundancy can support emergence and self-

organization (B. Davis & Simmt, 2003), and, thus, interprofessional education (McMurtry, 2010; Weaver et al., 2011).

Complexity Theory

Nunn (2007) stated there is "no generally accepted statement of what complexity theory is or how complex something must be to come with the ambit of complexity theory" (p. 378). To this end, Hogan (1995) reported 35 definitions of complexity theory in the literature. Likewise, Wallis (2009) suggested conceptual confusion surrounding complexity theory might reflect validity of the theory or the number of voices involved in the conversation. The absence of a definition does not equal the absence of validity. For example, B. Davis et al., (2007) suggested definitions of complexity are often reflective of the phenomenon under study. Clearly, there are inherent challenges in accurately using complexity theory to study phenomena of interest—defining complexity theory is elusive. However, concepts that comprise complexity theory appear more accessible for use as a theoretical perspective because they are more often described and defined within the complexity theory literature. The concepts I have chosen are not intended to represent a comprehensive review of complexity theory. Instead, in the following section, I will present findings from a review of the literature organized around the following four concepts: emergence, self-organization, diversity, and redundancy.

Emergence. Although some have referred to emergence as a theory in itself, (Holland, 1998), in the context of my research, emergence is a concept of the broader complexity theory. Emergence relates to phenomena that arise due to the interactions of agents (Morowitz, 2004; Sturmberg & Martin, 2013; Wolf-Branigin, 2013).

As a theory, emergence, like complexity theory, is broad. For example, Morowitz (2004) used 28 instances to illustrate how emergence has contributed to everything from the solar system to cells to agriculture. Likewise, Corning (2002) reported that emergence is "the reason why there are hurricanes, and ecosystems, and complex organisms like humankind, not to mention traffic congestion and rock concerts" (p. 2). Clearly, a concept that is broad enough to apply to 28 changes within the history of the universe and explain events from hurricanes to rock concerts is not a simple concept to define, and, thus, not surprisingly, definitions vary. For example, Wolf-Branigin (2013) defined emergence as "the structures and functions that arise from the interactions of agents" (p. 276). A. Davidson, Ray, and Turkel (2011) defined emergence as "creative and innovate change [occurring] at the edge of a system where there is the most disorganization and disorder" (p. 7). From these two definitions, emergence refers to processes that occur away from the level that caused them to occur. Although I am cautiously offering a definition of a concept that elusively defies definition, I am explicating my view that emergent phenomena are visible only at a distance from the initial interactions that initiated the emergence. Likewise, I am aligning my definition with Goldstein's (1999) definition of emergence: "the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems" (p. 32). I will discuss self-organization in more detail in subsequent sections. However, for the purpose of a discussion on emergence, self-organization refers to the self-generated and creative behavior of a complex system (Goldstein, 1999). In other words, emergent phenomena are a result of self-organization of agents within a system.

Several authors (e.g., Goldstein, 1999; Manson, 2001) suggested emergence helps explain how it is possible for a whole to be more than the sum of its parts. In the absence of emergence, a whole may be the additive sum of it's parts. However, as Stanley (2005) clarified: "a car is not a traffic jam, and a person is not a riot" (p. 32)—a point that helps explain the non-additive component of a whole being more than the sum of its parts and provides a foundation from which to apply emergence. If we conceptualize a riot as an emergent phenomena, that is the riot was produced by the self-organizing and nonlinear interactions of the agents (i.e., multiple people), the interactions between these agents, or parts of a system, contribute to making the whole greater than the sum of its parts. Again, although obvious, it is based on the assumption that one cannot understand an emergent phenomena through a reductionist lens because compartmentalizing and isolating the agents that give rise to the phenomena will not capture the active ingredients of that phenomena (e.g., interactions). Returning to Goldstein's (1999) seminal work on emergence, "emergence is appealed to when the configuration of the components of a complex system offers more explanatory insight into the dynamics of the system than do explanations based on the parts alone" (p. 57).

During interprofessional education, students from different professions are engaged in learning with, from, and about each other (Centre for the Advancement of Interprofessional Education, 2002). Given the variation of what is possible to be learnt, and from whom, small actions of agents within the system can result in large unpredictable changes in the learning of the overall system—these changes can be said to emerge from smaller adaptations. The configuration of a system, especially the interactions between agents within a complex system, is an appealing perspective to

explore interprofessional education. Several authors (B. Davis & Simmt, 2003; B. Davis et al., 2007; Fazio & Gallagher, 2009; Stanley, 2005; Weaver et al., 2011) have suggested that learning can be conceptualized as an emergent phenomenon in the context of complexity theory. Such a conceptualization permits refocusing of learning within interprofessional education away from individuals learning separately and towards a group learning collectively (McMurtry et al., 2016) or, as B. Davis and Sumara (2001) state, a learning system.

Self-organization. Self-organization is a concept of complexity theory that overlaps with emergence. Likewise, similar to emergence, self-organization has also been referred to as a theory (see, for example, Heylighen, 2001) which explains its broad appeal within multiple disciplines to describe complex phenomena. The term was first discussed in the fields of thermodynamics and cybernetics in the 1950s and 1960s (Heylighen, 2001) and has since permeated many areas of research. For my proposed research, I am following the approach used by Stanley (2005) and locating self-organization as a concept of the broader complexity theory. This approach has been used by other researchers who used the concept to explore emerging phenomena (see, for example, B. Davis et al., 2007; Wolf-Branigin, 2013).

Similar to other discipline-spanning terminology employed within the complexity landscape, several definitions of self-organization exist in the literature. Goldstein (1999) offered a definition of self-organization that emphasized changes within an entire complex system: “the term refers to the creative, self-generated, adaptability-seeking behavior of a complex system” (p. 56). Other authors (B. Davis et al., 2007; Heylighen, 2001; Manson, 2001; Stanley, 2005) suggested self-organization refers specifically to the

interactive changes that the components of a system undertake that eventually give rise to an observable change in the system. These local level changes occur without external or internal control and result in the observable appearance of a new structure or pattern at the whole system level. One of the most common examples of self-organization is a flock of birds: no bird is ultimately in charge, all follow a common set of rules for flight, and no bird is aware of how the overall flock appears externally. In essence, the birds self-organize and, in doing so, create a flock. There is overlap with emergence given the flock has emerged from the self-organization of the birds. Through this example, one can see how self-organization describes how changes at the system level can result from local interactions of agents.

Self-organization depends on local interactions between agents. As agents within a system adapt, their adaptations influence how the other agents within the system adapt and change, which, in turn, influences how the first adaptations continue to change. In essence, there is feedback built into the system that helps direct local interactions. This feedback is concomitantly occurring with feedback from other agents within the system; thus, the overall change of the system is virtually unpredictable. Reactions of agents to feedback can be both counteractive and cumulative across agents (Heylighen, 2001). As a result of these changes, emergence of new phenomena is supported.

The concept of self-organization within complexity is aligned with interprofessional education. Recall, interprofessional education occurs when students from more than one profession learn with, from, and about each other (Centre for the Advancement of Interprofessional Education, 2002). Likewise, as I previously illustrated, interprofessional education can be conceptualized as a complex learning system. These

two points have important implications for how self-organization can be used to understand interprofessional education. According to B. Davis and colleagues (B. Davis et al., 2007), from a complexity perspective, what is learned by a complex system is determined by the system and not from an external source. When discussing self-organization in a learning context, B. Davis et al. stated that "the learning system determines what will be learned, not the event or experience that prompts learning to happen" (p. 81). This quotation is the crux of how complexity theory and its associated features and aspects may begin to provide a useful lens for exploring within interprofessional education. The fit between self-organization and interprofessional education is twofold and relates to non-linearity and local interaction.

First, self-organization provides a theoretical perspective that does not assume linear predictable outcomes from proportional inputs and outputs. Weaver et al. (2011) suggested established theories of education are not easily applied to interprofessional education because they are often based on the assumption that learning goals can be predetermined, controlling inputs will predictably bring about these goals, and the endpoints of learning can easily be measured. B. Davis et al. (2007) referred to theories that rely on predetermined predictions of learning as correspondence theories because they are mostly concerned with how well mental constructs correspond with the physical world. When viewing learning from these perspectives, a teacher would use a linear path and predetermined materials to teach and subsequently evaluate how well a student learned by measuring correspondence between mental constructs and physical reality. Weaver et al. argued this type of control is not possible in interprofessional education given the unpredictability and lack of external control inherent in a group that is learning

from and about each other. Likewise, Fazio & Gallagher argued a similar stance in their research examining teacher development: "using linear or reductionist principles fails to capture the inherent complexity of effective teacher development learning phenomenon" (Fazio & Gallagher, 2009, p. 2). Self-organization, with its emphasis on how changes by agents within a system help change the overall system in unpredictable ways, is clearly a departure from correspondence based theories relying on predictability and linearity.

Second, it is useful to return to the idea that a learning system determines what can be learned. I have established that interprofessional education can be conceptualized as a complex learning system, and, thus, it is feasible to suggest learners within interprofessional education play an important role in determining what is to be learned. For learning to occur from and about each other, learners within the system must also be engaged as teachers while concurrently learning and thus changing (e.g., changing perspectives, actions, beliefs, assumptions, etc.). These changes ultimately affect how and what they feedback (i.e., teach) to other agents within the system. As a result of these local level interactions, the entire system changes and learns but not as a result of any external or internal control. In the following section, I will present findings from review of the literature on diversity and redundancy. As these concepts are complementary, I will first present a section describing how they related to this research, and, then, I will present each separately.

Diversity and redundancy as complementary concepts. B. Davis and Simmt (2003) identified several attributes of complexity theory as necessary for complex learning systems to learn—two of which were diversity and redundancy. Diversity and redundancy enable and constrain broader attributes such as self-organization and

emergence (B. Davis & Simmt, 2003). In other words, diversity and redundancy support self-organization and emergence. Recently, Weaver and colleagues (Weaver et al., 2011) extended the notion of diversity and redundancy to interprofessional education when they explored how complexity theory could be used to understand interprofessional education development from the perspective of those developing the experiences. They reported the development of an interprofessional education initiative could be understood using complexity—including, but not limited to, diversity and redundancy (Weaver et al., 2011). Importantly, Weaver and colleagues supported the notion that diversity and redundancy are present within interprofessional education (albeit, the development aspects) and that diversity and redundancy could be used to code qualitative data to explore interprofessional education from a complexity perspective. Even more recently, McMurtry and colleagues (McMurtry et al., 2016) argued that diversity from a complexity theory perspective offers an opportunity to reconceptualize interprofessional learning to align with the complex reality of interprofessional education. In the following sections, I examine diversity and redundancy separately.

Diversity. As with previous concepts presented, many definitions and applications of diversity exist. For example, Arrow and Henry (2010) suggested the majority of research exploring diversity in the workplace has focused on how different people look (e.g., race, ethnicity, gender, age, etc.) as opposed to cognitive diversity. They argued for a shift in how diversity is studied: "the key diversity resource for generating complex interaction, adaptation, and learning is not people who look different, but people who think differently, can do different things, and bring different approaches to bear in processing information" (Arrow & Henry, 2010, p. 863). Page (2008) offered a

similar perspective on diversity. Specifically, he suggested diversity comes in four kinds: diverse perspectives (ways of representing problems), diverse interpretations (ways of categorizing perspectives), diverse heuristics (ways of generating solutions), and diverse predictive models (ways of deducing cause and effect) (Page, 2008, p. 7). Although Page (2008) contradicted Arrow and Henry (2010) by suggesting identity diversity (i.e., diversity of how people look) is an important factor in problem solving processes, Page noted identity diversity relates to cognitive diversity when solving problems or overcoming challenges. Interestingly, my scoping review suggested health sciences researchers do not distinguish between cognitive and identity diversity, with some authors (see, for example, Anderson, Toles, Corazzini, McDaniel, & Colon-Emeric, 2014) referring to diversity as diversity of cognitive schema and suggesting diversity arises from social, educational, cultural backgrounds, organizational roles, and age.

Diversity is clearly multifaceted. Teasing apart, or prying apart, as per B. Davis and Simmt (2003), the various kinds of diversity that combine to support processes in complex learning systems (i.e., self-organization, emergence) is a daunting task. Page (2008) stated:

> Yes, race, gender, and ethnicity matter, but so do our *experiences*: the friendships, road trips, chance meetings, and pancake breakfasts that combine to form a life. Education and training also influence our collections of cognitive tools. Diversity has many causes. That's good. (p. 15)

Moving forward, I take an approach to diversity guided by B. Davis and Simmt (2003), B. Davis and Sumara (2006), McMurtry (2010), and Page (2008). Diversity refers to the different contributions learners make to the learning collective contributing to the overall

collective's intelligence (McMurtry, 2010). In their research on mathematics education, B. Davis and Simmt used diversity to identify how people contributed to collective learning in different ways. They stated that "one cannot specify in advance what sorts of variation will be necessary for appropriately intelligent action, hence the need to ensure the presence of diversity" (p. 148). B. Davis and Simmt identified examples such as interjections of actions, additions of contacts, and sharing of information. Likewise, they suggested a certain level of complexity and diversity is present in learning collectives regardless of how homogenous the group appears—thus it is a reasonable assumption that various levels of diversity will be present in my data (B. Davis & Simmt, 2003; B. Davis & Sumara, 2006). The assumption that a certain level diversity exists in all learning groups is imperative as Stanley stated: "without diversity, therefore, the possibility for novelty, new insights and on-going learning is not likely to happen or is apt to be diminished" (p. 125). By identifying instances of diversity within a collective learning group, we may eventually move to answering the question: "how can it be made to happen?" (B. Davis & Simmt, 2003, p. 144).

Redundancy. Redundancy is a complementary concept to diversity. B. Davis and Simmt (2003) suggested redundancy refers to "duplications" and "excesses" (p. 150) of contributions that are necessary for certain events to occur. They pointed out how the term redundancy is often associated with inefficiency or wastefulness when discussing complicated systems (e.g., a machine) where efficiency is key. However, when applied to a complex system, redundancy takes on a meaning of adequacy due to the constantly changing (emerging) nature of complex systems (B. Davis & Sumara, 2006). Adequate

redundancy of a system refers to the necessary sameness of agents (i.e., learners) to support interaction between agents and compensation of shortfalls.

In the context of education, especially in the context of a learning collective, redundancy is necessary (B. Davis & Simmt, 2003). B. Davis and Simmt (2003) highlighted two benefits of redundancy to a collective of learners. First, from a practical standpoint, redundancy permits interactions between learners. In other words, a certain level of sameness is required between learners to facilitate interaction and support learning. In an interprofessional education context, an example of facilitated interaction due to redundancy is how learners would need to possess common knowledge to interact. Second, redundancy enables agents (i.e., learners, clinicians, workers, etc.) to compensate for shortcomings and, thus, fill gaps. In the context of interprofessional education, the shortcomings and gaps are not found in individual learners' knowledge, but rather in the sharing of knowledge (and care for a patient) within the group. In other words, affording some over-lap in what the individuals can share in a case discussion about a patient's care ensures that if one agent is unsure of how to proceed (or what to share), a second agent is able to interject and offer a similar perspective and thus move the case/discussion forward. Such benefit would only be realized if the case study were designed to capitalize on the redundancy of learners—something that B. Davis and Sumara (2006) suggested represents an important education technique used to manipulate redundancy within a complex learning system. As B. Davis and Simmt (2003) and McMurtry (2010) noted, redundancy is complementary to diversity. The sameness created by redundancy functions in parallel to the difference created by diversity—both are necessary ingredients within a complex learning system. "Sameness among agents—in background,

purpose, and so on—is essential in triggering a transition from a collection of *me's* to a collection of *us*" (B. Davis & Simmt, 2003, p. 150). Although some redundancies can be expected to exist in the background, complexity theory can help educators capitalize on their existence, thereby supporting other complexity attributes such as self-organization and emergence.

Moving forward, I will use redundancy as my second coding category. Drawing on B. Davis and Simmt (2003), B. Davis and Sumara (2006), and McMurtry (2010), I use the notion of redundancy (or commonality in the case of McMurtry) as sameness that supports interaction and gap-filling. I will use redundancy to identify instances (in the focus group and observational data) of similarity between agents that appear to contribute to learning within interprofessional education.

Summary of Literature Review

Interprofessional education has been described in the literature as occasions where individuals from at least two professions learn with, from, and about each other to improve collaboration and patient outcomes. It has been a focus of investigation for several decades. However, recent interest from governments has spurred several key reports to be produced. Likewise, there has been an increase in research examining interprofessional education. Despite this research, it is still largely unknown how best to support interprofessional education and the field of inquiry suffers from several methodological drawbacks. As a result, authors have called for increased use of theory to inform studies examining interprofessional education. There is no overarching interprofessional education theory and no single agreed upon theory from another discipline. Instead, there are multiple theories from which to draw from. A new theory

that has attracted interest from scholars examining interprofessional education is complexity theory. Complexity theory offers a perspective of a system while not relying on a reductionist approach to do so. Within complexity theory, the concepts of self-organization and emergence exist. Self-organization and emergence are supported by the concepts of diversity and redundancy. These concepts may offer a useful lens through which to study interprofessional education and thereby help contribute to a better understanding of what it means to learn with, from, and about each other across professional boundaries. A better understanding could lead to improve curriculum design and assessment of interprofessional education. Furthermore, it could help conceptualize interprofessional education in a manner that helps strengthen ongoing research examining how best to design and implement interprofessional education.

CHAPTER THREE: METHODOLOGY AND METHODS

In Chapters 1 and 2, I argued a problem exists in the field of interprofessional education due to the lack and type of theory used to inform interprofessional education research, an underdeveloped, or early, conceptualization of interprofessional education, and an emphasis on individual learning and outcomes. To address this problem, I used a scoping review and case study to explore interprofessional education from a complexity theory perspective. In Chapter 3, I outline the methodology and methods and provide rationale for how I conducted my research.

Conventionally, research questions come from identifying gaps in the literature (LoBiondo-Wood, Haber, Cameron, & Singh, 2012). Research findings would traditionally fill an identified gap and, thus, advance a field of study. However, as Alvesson and Sandberg (2011) suggest, "gap-spotting means that the assumptions underlying existing literature for the most part remain unchallenged in the formulation of research questions" (p. 247). Alvesson and Sandberg argue that when researchers identify a gap in the literature and subsequently fill the gap with their research findings, they are supposing the body of literature on either side of the gap is based on correct assumptions.

In my experience reading and attempting to implement the findings from interprofessional education research, certain assumptions underlying literature in this area were shown to be problematic and open to challenge. Therefore, for my doctoral research, I used complexity theory to understand how interprofessional education occurs as a complex system. I have not identified a gap in the literature per se. Instead, I offer a complementary perspective on a topic that has been studied using largely unquestioned traditional methods. McMurtry and colleagues recently highlighted the problem of

relying upon traditional methods to study interprofessional education: “established approaches to interprofessional learning and assessment are buttressed by the traditional assumption that individuals’ minds are containers that acquire knowledge and then produce behaviour as an output” (McMurtry, Rohse, & Kilgour, 2016, p. 170). I aimed to explore interprofessional education using complexity theory in a manner that challenges underlying assumptions in the field (e.g., adult learning theory is most appropriate for interprofessional education, focusing on individuals in groups is most important, interprofessional education is learned through acquisition of knowledge in the same way a glass is filled with water) as opposed to filling self-identified gaps in the literature. To accomplish this, I used a form of literature review known as a scoping review (Arksey & O’Malley, 2005; Levac, Colquhoun, & O’Brien, 2010) and qualitative case studies (Yin, 2013).

Scoping reviews are a systematic method for synthesizing a range of literature to answer research questions (Colquhoun et al., 2014). Case studies are a form of qualitative research used to study an issue or phenomenon best understood within its context (Creswell, 2007; Yin, 2013). Together, these two approaches are complementary. Scoping reviews can be used to map key theoretical concepts within a particular field (Reeves et al., 2011). Contrary to other qualitative methods (e.g., grounded theory, ethnography), case studies benefit from employing theory prior to data collection. Therefore, I used the scoping review findings to inform the theory that guided my case study. In the following sections, I present each methodology, and their inherent methods, separately. The scoping review section is concise given the methods are simple with less options to chose from and, therefore, less rationale to provide. In the case study section, I

present an overview of case study methodology and rationale for why I chose Yin (2013), an overview of the four frameworks I used to design and implement the interprofessional education activity (i.e., my cases), an overview of the interprofessional simulation, and the specific methods I used within the case study methodology.

Scoping Review Study

Scoping review methodology. During the last 25 years, the evidence-based practice movement in health care has led to the development of different forms of literature reviews (Grant & Booth, 2009; Whittemore, 2005; Whittemore & Knafl, 2005). At first, the emphasis was on finding the most effective treatment options for patients. As such, systematic reviews took precedence over other. Systematic reviews were developed to overcome the inherent biases and lack of precision of traditional reviews (Whittemore, 2005). The emphasis placed on systematic reviews expanded into other professions, such as education (Andrews, 2005; Evans & Benefield, 2001). The move to objectivity and precision became the raison d'etre of systematic reviews: "Gathering research, getting rid of rubbish and summarizing the best of what remains captures the essence of the science of systematic review" (Grant & Booth, 2009, p. 92). However, similar to many concepts in health and education, the term *rubbish* is equivocal. For example, in an editorial in *The Bulletin* (a leading public health journal published by the World Health Organization), the editor acknowledged both the importance and challenges of systematic reviews for answering public health questions (Petticrew, 2009). Similar examples of authors acknowledging the applicability of current systematic review methods for answering questions of a social nature are also found in education (Andrews, 2005). As a result, in the past decade, the need for evidence-informed policy- and decision-making—processes

inherently subjective and complex—has led to a shift to broader review methods (Grant & Booth, 2009; Whittemore & Knafl, 2005). This shift presents researchers with multiple options when choosing how to answer research questions using reviews. Additionally, as Grant and Booth point out, systematic consideration of existing research to answer research questions presents an economical approach to knowledge generation.

In their review of review methods, Grant and Booth (2009) identified 14 types of reviews. Although these 14 review types differ in purpose, strengths, and weaknesses, there is considerable overlap. Using Grant and Booth's work as a guide, I reviewed the 14 types of reviews available to determine which approach was best suited to answer my first research question of how complexity theory has been incorporated in health services research. In determining the approach, I had to consider the resources, research question, research purpose, and anticipated literature. I selected a scoping review methodology.

Scoping reviews are an evolving methodology for synthesizing literature (Arksey & O'Malley, 2005; Colquhoun et al., 2014; Daudt, Mossel, & Scott, 2013; K. Davis, Drey, & Gould, 2009; Levac, Colquhoun, & O'Brien, 2010; Pham et al., 2014; Valaitis et al., 2012). A scoping review methodology was appropriate for my purpose as scoping reviews aim to map a body of literature (as opposed to report on evidence) that is often broad (as opposed to narrowly focused on a topic) and comprised of a range of study designs and methodologies (as opposed to homogenous study design or limited to quantitative methodology) (Arksey & O'Malley, 2005; Brien, Lorenzetti, Lewis, Kennedy, & Ghali, 2010; Levac et al., 2010; Pham et al., 2014). As my purpose was aimed at exploring how complexity theory has been incorporated in health services literature, in an effort to better understand how complexity could be used to explore

interprofessional education, I was not aiming to report on the effectiveness of an intervention within a narrow topic comprised only of quantitative studies. I anticipated vast heterogeneity and a scoping review approach accommodates such variation. In the following section, I address the specific details of the scoping review methods I followed.

Scoping review methods. I employed the most widely used approach to scoping reviews outlined by Arksey and O'Malley (2005) and advanced by Levac and colleagues (Levac et al., 2010). Following their approach, scoping reviews involve five steps: (a) identifying the initial research question; (b) identifying the relevant studies; (c) selecting the studies; (d) charting the results; (e) collating, summarizing, and reporting the findings; and (f) consulting stakeholders for knowledge translation of findings. With the exception of consultation of stakeholders (because there were no stakeholders appropriate to my research question), I followed Arksey and O'Malley's approach and used Levac et al. as a guide for how to operationalize each step. As the scoping review study comprises a stand-alone manuscript in this dissertation, there is some repetition between the following section and the methods section in Chapter 4. However, I have written these sections differently to avoid plagiarism.

Identifying the initial research question. An important component of a scoping review is defining the research question and protocol (Levac et al., 2010). For my research, I first developed a scoping review protocol that outlined the research question, databases to be searched, inclusion criteria, exclusion criteria, and data to be extracted. Defining terms for clarity is often a challenge in scoping reviews (Valaitis et al., 2012). Defining terminology was difficult for my review, because it required terms such as *complexity theory* and *health services research* to be clearly defined. Through an iterative

process augmented by pilot-testing several search strategies, I was able to define these terms and identify the research questions that would guide the scoping review (as outlined in Chapter 1).

Identifying relevant studies. While identifying the research question, I developed the search strategy in consultation with my doctoral supervisor and a Master of Library Information Science (MLIS) Librarian. I conducted the search between June 2014 and June 2015 using The Cochrane Database of Systematic Reviews, CINAHL, EMBASE, Medline, and Web of Science. Table 3.1 outlines the search strategy for each database. Due to the broadness and ambiguity of complexity theory, I used a variety of search terms. In addition to database searching, I conducted citation searching of key articles. Once I compiled a list of included studies, I shared this with an expert in the field who agreed to review. Unfortunately she did not respond after I shared the references.

Table 3.1

Database Search Strategy

Database	Search Strategy
CINAHL	complexity theory OR complexity science OR complex adaptive system OR complexity thinking OR complex responsive process theory OR chaos theory
Cochrane Database of Systematic Reviews	complexity theory OR complexity science OR complex adaptive system OR complexity thinking OR chaos theory OR complex responsive process theory
EMBASE	complexity theory OR complexity science OR complex adaptive system OR complexity thinking OR chaos theory OR complex responsive process theory
Medline	complexity theory OR complexity science OR complex adaptive system OR complexity thinking OR chaos theory OR complex responsive process theory
Web of Science	TS=("complexity theory" OR "complexity science" OR "complex adaptive system" OR "complexity thinking" OR "complex responsive process theory" OR "chaos theory") *DocType=All document types; Language=All languages*

Study selection. My inclusion criteria consisted of the following:

- Published in a peer-reviewed journal
- Written in English
- A statement from authors stating they incorporated complexity theory in their research
- A phenomenon related to health services research was studied
- Nurses, physicians, or allied health professionals were studied

I did not exclude studies based on study design. I excluded articles describing quality improvement projects and included articles describing quality improvement research or research on quality improvement techniques. I excluded quality improvement projects because quality improvement projects differ from research. Specifically, quality improvement projects are often focused on describing improvements to care for a specific population or organization while quality improvement research or research in general is aimed at developing new generalizable knowledge (Newhouse, Pettit, Poe, & Rocco, 2006). I struggled with distinguishing between quality improvement and research reports because there is overlap (Morris & Dracup, 2007). I used an approach by Newhouse et al. (Newhouse et al., 2006) that suggests assessing intent of authors, burdens and risks to subjects, and oversight of the project.

I used the Canadian Institute of Health Research definition of health services research (Canadian Institute of Health Research, 2014). I excluded studies explaining aspects of diseases (e.g., atrial fibrillation, cerebral vascular accidents) and excluded commentary or discussion articles of complexity theory.

I defined allied health professionals as dietitians, occupational therapists, pharmacists, physiotherapists, and speech-language pathologists. Studies that involved additional professions were included if they focused primarily on nurses, physicians, or allied health. I included only the results pertaining to the seven professions above when studies included additional professions. I excluded studies that focused on pre-licensure students in an effort to focus the scoping review. I did not use date limits on my search.

I screened titles and abstracts first and then reviewed full text articles that met inclusion criteria. My supervisor reviewed articles that were difficult to determine

inclusion/exclusion (i.e., quality improvement articles). I used web-based bibliographic software (Zotero™) to organize articles. Use of technology is recommended for managing scoping reviews (Valaitis et al., 2012)

Charting the data. I extracted data related to each sub-research question as recommended by Arksey and O'Malley (2005). I then entered data into a Microsoft Excel™ spreadsheet and created individual tables for analysis. I included data on authorship, publication year, country of research, research design, professions involved, setting of research (e.g., long term care, acute care), interprofessional focus, purpose/objective of research, attributes of complexity theory used, phenomena of interest, how complexity theory was used, and definition/description of complexity theory provided. I attempted to use NVivo™ as suggested by Valaitis and colleagues (Valaitis et al., 2012), but the process was cumbersome and unmanageable.

Collating results. A framework should be used to collate results (Arksey & O'Malley, 2005). I used my scoping review research questions to create a framework. For the first question, I created a data table for study characteristics (first author, year published, country, and study design). Second, I created a data table for the professions involved, the area of research, the setting of research, and whether the research focused on interprofessional collaboration or education. I compared characteristics, setting, and profession across all studies to answer the first two research questions. I then categorized studies based on their research purpose using the verb used in their purpose statement (e.g., describe, explain, explore). I categorized how authors used the verb, despite potential overlap. Although verbs may overlap for research purposes (e.g., describe and explore), I aimed to minimize the subjective interpretation at this stage. I then determined

the phenomena of interest for each study by reviewing all research purposes and identifying commonalities across phenomena. I categorized studies by research purpose and compared the phenomena of interest within and between categories. I then identified how researchers used complexity theory in their study (e.g., conceptual framework, data analysis, interpret findings). Finally, I created a data table of the descriptions of complexity theory from each study. I used this table to determine what attributes of complexity theory authors used. I followed an approach used by Wallis (2008) in his review of complexity in the organizational theory literature to organize attributes. Specifically, I compiled attribute descriptions (i.e., conceptual components) using author definitions and descriptions and grouped attributes together when it appeared they were describing the same thing. For example, I combined *relationships* and *connections* as *relationships*. I then explored themes between descriptions.

Quality assessment within scoping reviews. A criticism of scoping reviews is the lack of assessment of included studies' methodological quality. Recently, some authors (e.g., Daudt et al., 2013; Pham et al., 2014) have suggested scoping review authors consider assessing the methodological quality of included studies. However, such assessment is rare. For example, despite Daudt et al. (2013) advocating for quality assessment, they did not perform such assessment in their own review. After careful consideration, I decided against such assessment for two reasons. First, the framework I used to construct this review did not call for a methodological assessment of included studies (Arksey & O'Malley, 2005; Levac et al., 2010). Despite some discussion recently about including methodological assessment in scoping reviews (Daudt et al., 2013; Pham et al., 2014), the most current scoping review methodology (Colquhoun et al., 2014),

although considering assessment of methodological quality, recommends following the approaches outlined by Arksey and O'Malloy (2005) and Levac et a. (2010). Second, calls for including methodological assessment in scoping reviews are based on a need to grade the level of evidence for results of scoping reviews being disseminated primarily for use in practice and policy decisions (Daudt et al., 2013). Daudt and colleagues recommend a decision to perform methodological assessment should be made in conjunction with the purposes of the scoping review (Daudt et al., 2013). Pham et al. (2014) state that methodological quality could be used to find gaps in an evidence base. My research purpose was not aimed at a practice or policy problem and I did not anticipate results being disseminated to either area in a manner where a judgment on the quality of included studies (i.e., evidence base) would be necessary.

Case Study

Case study methodology. A qualitative approach was the best fit for my research. Qualitative research "is a practice of empirical inquiry focused on naturally occurring phenomena" (Bassil & Zabkiewicz, 2014, p. 166). The focus of qualitative research is on making sense of, or interpreting, phenomena within the context of a natural setting (Denzin & Lincoln, 2011). According to Creswell (2007), qualitative research should be used when an investigator cannot separate the participants from the context or when "partial or inadequate theories exist for certain populations and samples of existing theories do not adequately capture the complexity of the problem we are examining" (p. 40). As I stated in Chapters 1 and 2, existing theories have not captured the complexity of interprofessional education, and, thus, I am attempting to explore interprofessional education, in a natural setting, using complexity theory.

There are many approaches to qualitative research (Creswell, 2007; Denzin & Lincoln, 2011). While I carefully considered several approaches (i.e., ethnography, phenomenology, narrative inquiry, and grounded theory), a case study approach was most closely aligned with my research aim. Case studies are a form of qualitative research used to study an issue or phenomena in the natural context where it occurs and to answer research questions focused on understanding social or organizational processes. (Creswell, 2007; Hartley, 2004; Yin, 2013). Baxter and Jack (2008) recommend several circumstances where case study research would be the best methodology to explore a phenomenon:

- If the research question being answered pertains to "how" or "why" and is therefore exploratory in nature;
- If the researcher has little control over the behavioral events being studied;
- If the research is focused on contemporary events as opposed to historical events;
- If the research believes that contextual elements are particularly relevant to the phenomenon of interest and the boundaries between the phenomenon and context are not decipherable (p. 545).

My research satisfied these circumstances given that I was seeking to answer "how" questions by studying contemporary events while exerting little control over the subjects as they learn with, from, and about each other (i.e., experience interprofessional education) within a natural context.

According to Creswell (2007), two foundational authorities on case study research are Yin (2013) and Stake (1995). Both authors agree that case study research is best suited to study a phenomenon of interest within its context from many different

perspectives. However, from my interpretation, as well as the interpretations of others (Baxter & Jack, 2008; Brown, 2008), a key difference between Yin and Stake is the role of the researcher in the case study. Comparing Yin and Stake, Yin's approach to case study research is slightly more focused on the process of conducting the case study (i.e., the methods), whereas Stake is more focused on locating the researcher as an interpreter of the findings. For example, in the context of analysis, Stake (1995) states "analysis essentially means taking something apart…we take our impressions, our observations apart" (p. 71). Both Yin and Stake are clear that case study research is based upon a constructivist paradigm (Baxter & Jack, 2008). However, Stake's description of analysis within case study research places the emphasis on the researcher interpreting the researcher's understanding of the data. Although this is logical, Stake does not offer any guidance on how a researcher should carry out interpretation. Conversely, Yin places slightly more emphasis on developing an analytical framework for how to proceed through data analysis—at least at case level. More broadly, Yin offers the reader a more structured and detailed description of how best to proceed through case study research. As a novice researcher conducting case study research, I used Yin's approach to case studies as he offered the necessary guidance and direction I required. I was aware that I risked positioning case studies as a method (i.e., a focus on the techniques) more than a methodology (i.e., the assumptions inherent in the techniques), and I explicitly aligned myself with Creswell's (2007) view of case studies as methodology— yet I required Yin's guidance on the methods.

In my research, the phenomenon of interest was interprofessional learning. The context was an interprofessional education activity (i.e., the activity aimed at supporting

at least two professions learning with, from, and about each other). Setting boundaries on a case is an important component to case study research (Baxter & Jack, 2008; Yin, 2013). Without boundaries, data collection becomes broad and difficult to manage (Yin, 2013). My cases were interprofessional learning that occurred within interprofessional education sessions. Although some may criticize the choice of performing a case study on such a time-limited event, Yin points out that case studies do not need to be time intensive approaches resulting in reams of unmanageable data. The phenomenon of interest was naturally located within a time-limited interprofessional education activity.

Yin (2013) describes several case study designs. My research used a multiple holistic case study design. The term *holistic* denotes there were no subunits within my cases. Said another way, the cases I studied were interprofessional learning activities and there were no smaller cases within those activities (i.e., no embedded cases). A multiple case study is akin to conducting multiple studies for the purpose of seeking either similar or contrasting results and multiple case study design is thought to be more robust (Yin, 2013). Specifically, I used multiple case studies in a replication sense, which is similar to replicating a study as opposed to increasing the sample size. The approach I undertook was similar to Weaver et al.'s (2011) work where they used aspects of complexity theory to categorize data and then identified themes within that data—albeit in their work, the complex system under study was a group of stakeholders charged with designing and interprofessional education activity for health students on placement and my focus is the students participating in an interprofessional education activity. Further, several studies in my scoping review demonstrated that attributes of complexity theory could be used to

inform data categorization (Thompson et al., 2016). In the following section, I describe the methods starting with the interprofessional education activity.

Case study methods.

The interprofessional education activity: The context for the cases. I originally planned the study to coincide with a student-led interprofessional education event. However, there were changes in the student-led event making a partnership unfeasible. Therefore, I undertook planning and implementation of an interprofessional education simulation of my own for this study. I obtained the necessary amendment approvals from two university research ethics boards.

An interprofessional education activity formed the context for the cases. Each identical session was approximately three hours and consisted of six stages (Figure 3.1). See Appendix A for a detailed overview of all stages.

Figure 3.1. Stages of interprofessional education activity. This figure illustrates the six stages of the interprofessional education activity.

There are no comprehensive simulation frameworks for designing scenarios focused on interprofessional education. Therefore, to design this simulation, I combined four existing frameworks published in the interprofessional education literature and the simulation literature. The frameworks I used included the Canadian Interprofessional Health Collaborative: National Competency Framework (Canadian Interprofessional Health Collaborative, 2010), The University of Alberta Interprofessional Learning Pathway (University of Alberta, n.d.), University of British Columbia Model of Interprofessional Education (Charles, Bainbridge, & Gilbert, 2010), and the NLN/Jeffries Simulation Framework (Groom, Henderson, & Sittner, 2014). Collectively, these

frameworks provided necessary guidance for processes related to content area, level, and delivery of an interprofessional education simulation activity. A description of each framework and how I used each individually is presented in Table 3.2.

Table 3.2

Frameworks used for Interprofessional Education Simulation Design

Framework Name	Description and Use of Framework(s)
Canadian Interprofessional Health Collaborative: National Interprofessional Competency Framework (Canadian Interprofessional Health Collaborative, 2010)	Interprofessional Education Content This framework identifies the competencies that can guide interprofessional education. Furthermore, it provides specific descriptors and rationale for each competency. I used four competencies identified within this framework to guide the content of the pre-simulation education/discussion and simulation experience. Specifically, I discussed the following competencies with participants are: patient centered care, communication, collaborative leadership, and role clarification. I designed the simulation to cover these competencies (depending on how the students progressed through the simulation). I discussed these competencies with participants prior to the Stage A using the following document: http://www.cihc.ca/files/CIHC_IPCompetenciesShort_Feb1210.pdf
University of Alberta Interprofessional Learning Pathway (University of Alberta, n.d.) University of British Columbia Model of Interprofessional Education (Charles et al., 2010)	Appropriate Level of Simulation These documents provide similar conceptual frameworks for aligning interprofessional education with the needs and abilities of students at different points throughout their pre-licensure education (i.e., different skill-mixes based on year level). Both offer hierarchical models where interprofessional education activities move from a novice level (i.e., exposure) to a more advanced level (i.e., mastery). I used these documents as a guide to level the simulation. Specifically, I designed the simulation at an exposure level to ensure it was appropriate for the widest range of participants. The population I recruited from does not have access to a formal program of interprofessional education and interprofessional education at the host-university is sporadic so I had to assume some participants would be new to interprofessional education. Therefore, an exposure level interprofessional education session is most appropriate. The University of British Columbia describes exposure as the introductory stage where junior level learners are provided opportunities to learn with other professions and explore multiple

	professional perspectives. The University of Alberta describes exposure as the early stage where students explore concepts, values, and contexts related to interprofessional competencies.
The NLN/Jeffries Simulation Framework (Groom et al., 2014)	Simulation Design The NLN/Jeffries Simulation Framework was developed as an initiative to fill a gap in the theoretical underpinnings of simulation-based instruction. It consists of five constructs believed to be important for simulation design: objectives, fidelity, problem solving, student support, and debriefing. I used this framework as a guide to structure the design and implementation of the simulation.

Combining frameworks for developing the simulation. The NLN/Jeffries Simulation Framework, although based primarily on expert opinion as opposed to empirical testing, "represents the core constructs of the evolving methodology of simulation-based education in health care" (Groom et al., 2014, p. 343). The authors identify five constructs believed to be important for simulation design: objectives, fidelity, problem solving, student support, and debriefing.

The NLN/Jeffries Framework suggests that objectives are critical for an effective simulation experience (Groom et al., 2014). The authors recommend sharing the objectives and purpose of the simulation with participants prior to the simulation. I describing select Canadian Interprofessional Health Collaborative competencies (Canadian Interprofessional Health Collaborative, 2010) prior the simulation and stated how objectives related to each competency. Additionally, I provided participants with a copy of each of the objectives and competencies. Of note, the objectives were purposely broad to allow participants some options within the simulation (See Appendix B for a copy of the Case Scenario provided to participants).

The NLN/Jeffries Framework equates "fidelity" with "realism" of the simulation (Groom et al., 2014). Realism in simulation refers to how well the environment (i.e.,

simulation suite) matches reality (i.e., health care environment). However, Groom and colleagues suggest there is little evidence to support the assumption that higher fidelity equals better learning outcomes. Some authors suggest during immersive simulation, it is the social dynamic or interactions that are more important to learning than the realism of a simulator or recreated environment. In other words, creating an environment for interaction is perhaps more important than creating a health care environment. In this research, I used a simulator manikin that is controlled by an operator on a computer located in an adjacent room. The manikin could talk (by way of an operator) and demonstrate physical parameters such as breathing, pulses, blood pressure, respiratory rate, etc. The environment was similar to a hospital room. Students were not asked to wear uniforms but were asked to maintain respective professional roles during the simulation. Using such equipment and environment approaches a medium level of fidelity. Past simulations focused on interprofessional education at the host university have reflected similar levels of fidelity.

According to the NLN/Jeffries Framework, problem solving relates to the level of complexity of the scenario (Groom et al., 2014). The authors of the framework state the scenario should be leveled appropriately to the learner. I used guidance from the University of Alberta and University of British Columbia frameworks (see Table 3.2) to develop this scenario at the "exposure" level of interprofessional education problem solving. In other words, the scenario was at an introductory level with limited advanced problem solving required. The focus was on interprofessional collaboration competencies from the Canadian Interprofessional Health Collaborative (e.g., patient centered care, communication, collaborative leadership, role clarification) rather than profession

specific competencies (e.g., a medical procedure, cardio pulmonary resuscitation). The problem solving required for the scenario in this research was at a low level to ensure comfort and participation by all students regardless of background and level.

Authors of the NLN/Jeffries Framework suggest student support (or cuing) is important to assist students in progressing through a scenario as expected (Groom et al., 2014). Specifically, student support cues are frequently used to assist students during problem solving within a scenario. Cues are commonly used for high fidelity simulations where students must respond to a deteriorating physiological condition of a manikin. I designed the scenario to require minimal student support given that the problem solving level was low (i.e., an exposure level). I provided an orientation to the scenario at the outset and the written case study of the patient before entering the simulation was designed to prepare them for the experience. I was available throughout the scenario to provide cues if needed. Appendix C includes examples of cues.

According to the NLN/Jeffries Framework, debriefing should occur immediately following a scenario (Groom et al., 2014). Debriefing enables examination of what occurred and what was learned during the simulation. Debriefing occurred immediately following the scenario, involved the participants and myself, and served a dual role. First, the debriefing served pedagogical purpose by examining what was learned during the simulation. Second, the debriefing acted as a data collection method—it resembled a focus group and served a research role. By way of exploring what was learned and how (debrief), data was generated and shared by the group (focus group). Kamberelis & Dimitriadis (2005) suggest focus groups serve three concurrent overlapping functions:

pedagogy, politics, and qualitative research practice. Thus, I capitalized on the pedagogical and qualitative roles of focus groups.

Details of the pre-simulation, simulation, and post-simulation are in Appendix A. The Objectives, Background, and Stage A Pre-Simulation Questions were provided to students in writing (Appendix B) and discussed in the pre-simulation. Stage B was not provided to students in written form and constituted their simulation experience. Appendix C is the template for the simulation experience—the template was used as a general guide during the simulation and was required by research ethics boards. A description of Stage C (post simulation) is outlined in the data collection section as Stage C formed my focus groups.

Conceptual framework and case study propositions. Both Yin (2009) and Stake (1995) recommend using conceptual frameworks and/or theoretical propositions to guide case study research. A conceptual framework can act as a foundation for the case study and assist with data interpretation (Baxter & Jack, 2008). Miles and Huberman (as cited in Baxter & Jack, 2008) suggest conceptual frameworks help authors identify appropriate study participants, describe relationships between concepts, and organize data into groups. A drawback to using conceptual frameworks, as highlighted by Baxter and Jack, is that a conceptual framework can force a researcher to be deductive during analysis. As I will discuss in a subsequent section, my research is purposely deductive to start (by using an a priori codebook to categorize data) and thus a conceptual framework is appropriate.

Conceptual and operational confusion related to conceptual frameworks in educational research exists throughout the literature (Rocco & Plakhotnik, 2009); thus, a

clear description of how I employed a framework is warranted. In my research, the conceptual framework helped outline the key concepts to be studied (Miles & Huberman, 1994). The phenomenon under study was interprofessional learning during an interprofessional education activity. To conceptualize interprofessional learning, I argued, in Chapter 2, that a group of participants engaging in interprofessional education is akin to a complex system and thus can be studied using attributes of complexity theory. Therefore, using the language of Yin (2013), complexity theory is the conceptual framework for this research and will support the theoretical propositions. Such an approach is supported as "researchers have often attempted to understand health care organizations by using case study designs; however, these designs are only as good as the theoretical model driving the research" (Anderson et al., 2005, p. 670). As argued in Chapter 2, Anderson et al. (2005) suggest complexity science offers an incredibly useful tool for informing case studies. Thus, I am employing concepts of complexity theory as a conceptual framework for my case studies. Theoretical propositions in case studies are akin to hypotheses' in quantitative research and are used as a guide to focus data collection, guide data analysis, direct the scope of the study, and help form the basis for a conceptual framework (Baxter & Jack, 2008; Yin, 2013). For this research, my propositions came from complexity theory:

1. Aspects of complexity theory (e.g., diversity, redundancy) will be present when students learn (with, from, and about each other) in an interprofessional context.
2. Aspects of complexity theory will be present in different ways across the multiple case studies and this will influence interprofessional learning.
3. Aspects of complexity theory can be supported to occur by educators.

The first two propositions guided my research. The third proposition reflects the impetus for my research and represents the potential usability of my results—it does not guide my research per se but guides the potential application of results. Although only two propositions guided my research, "a common pitfall for the novice case study researchers is to include too many propositions and then find that they are overwhelmed by the number of propositions that must be returned to when analyzing the data and reporting the findings" (Baxter & Jack, 2008, p. 552).

I modified my propositions during the research to reflect changes to the focus of my research. There was no mention in the literature whether modifying propositions during a study is acceptable. However, given that propositions are meant to focus case study research and the focus of my research changed slightly when I had to develop my own interprofessional activities as opposed to partner with the student led group, it seemed logical that the propositions should also change.

Participant recruitment. I recruited a purposive sample of post-secondary students enrolled in health or social care programs at one medium sized university in Ontario. Health or social care programs at the university include kinesiology, medicine, nursing, psychology, and social work. Participants were recruited using posters throughout campus (Appendix D), contacting instructors via publicly available email addresses and providing a short presentation in their classroom outlining the research (Appendix E), and contacting existing interprofessional education/collaboration groups and to distribute posters via their networks. Participants were compensated with a $20 gift card to an unlicensed (does not serve alcohol) restaurant. I had ethical clearance to

recruit participants from a second university in Ontario if there was insufficient interest, however, further recruitment was not necessary.

Sample size considerations. Sample size in qualitative research depends on many considerations related to methodology (Creswell, 2007). For this research, sample size decisions were based on recommended simulation group size (Boet, Bould, Layat Burn, & Reeves, 2014; Jeffries & Rizzolo, 2006; Reese, Jeffries, & Engum, 2010), interprofessional educational group size (Hean, Craddock, & Hammick, 2012; Oandasan & Reeves, 2005), case study sample size (Yin, 2012; 2013), focus group sample size (Krueger & Casey, 2008; Redmond & Curtis 2009), number of focus groups (Krueger & Casey, 2008; Morse & Field, 1995) and number of cases (Yin, 2013).

I prioritized recommended simulation group size because it was the foundation for the interprofessional education and focus groups—without effective simulation, the interprofessional education could fail and jeopardize the focus group. Considering the suggestions from the literature, I aimed for 4–5 cases (and therefore 4–5 focus groups) consisting of 4-6 participants each case. Furthermore, recruitment of 4–5 cases consisting of 4–6 participants seemed feasible given previous interprofessional education events held at the host university usually attracted between 40–100 participants, and an estimate of the number of students (the population) I was recruiting from was approximately 2000 students.

Protecting risk to participants. Prior to recruiting for this research I obtained ethics approval from Lakehead University's Research Ethics Board (REB) (Appendix F) and the University of Windsor's Research Ethics Board (Appendix G). I obtained approval for necessary amendments.

The ethical considerations outlined in the Tri-Council Policy Statement (Government of Canada, 2016) were addressed in both REB applications. Recruitment documents such as posters (Appendix D) and participant information letters (Appendix H) informed participants of foreseeable risks, voluntary participation, right to decline answering questions, and right to withdraw from the research at any time. Likewise, participants were made aware that I would maintain confidentiality through data management techniques (secure storage, secure transfer, secure access) and anonymity in any dissemination (use of pseudonyms). Participants were also informed during recruitment and reminded during the research that focus groups cannot ensure participant confidentiality because other participants of the focus group are present. I reiterated the importance of maintaining confidentiality and asked participants not to discuss the content of the focus group with others during the research.

My research posed a small yet unique risk related to group vulnerability. At the time of the research I was a lecturer at the host university, therefore, risk associated with the dual teacher-researcher role existed (Ferguson, Myrick, & Yonge, 2006). Specifically, coercion (real or perceived) and the power relationship between faculty and the learners participating in the interprofessional education sessions could influence informed consent and continuing voluntariness of participation (Ferguson et al., 2006). I attempted to mitigate this risk by not recruiting from classes I was teaching. If, through recruitment via interprofessional education networks, my students volunteered for this research, I would not assess those students' work. I co-taught courses with colleagues and thus my colleagues agreed to assess the work of students who volunteered for this research.

Students enrolled in classes I taught would be identified by a checkbox on the consent form as outlined in my original application.

Data collection methods. A particular strength of case study research is the ability to collect data from various sources to explore a phenomenon from several different perspectives. Yin (2013) suggests one of the most important sources of data within case study research is an interview. He notes that interviews are not rigid and instead should be guided by the participants, but directed toward a general line of inquiry. Focus groups are a form of interviewing that is useful in case study research (Yin, 2012). Secondarily, observation is aligned with case study methodology given that case studies occur in natural environments (Yin, 2013). As such, I collected data using focus groups and observation.

Focus groups. I conducted semi-structured interviews using focus groups with students who participated in the interprofessional education activity. As recommended by Creswell (2007), I developed an interview protocol guided by my research questions and in consultation with my supervisor (Appendix I). I used the interview protocol to guide the conversation as opposed to guide a rigid and structured query (Yin, 2013). I audio recorded focus groups using QuickTime™ player on a laptop and, as a backup, a Sony Digital Voice Recorder. I video-recorded focus groups using a Sony Handycam™ as a third backup. Focus groups occurred immediately following the simulation and lasted approximately 60 minutes. I transcribed audio recordings immediately following focus groups and uploaded transcripts to NVivo 10™ for organization and analysis. I shared transcript files with my supervisor using the secure University of Windsor Large File Transfer service.

Direct observation. I used a form of direct observation called non-participant observation (Spradley, 1980). Specifically, I video-recorded participants and the recordings comprised my field notes for analysis (Crabtree & Miller, 1991). Direct observation is useful in case study research given the phenomenon of interest is often being studied in the natural context (Crabtree & Miller, 1991; Yin, 2013). Observations were guided by my research questions. Specifically, I observed for examples of concepts of complexity theory, specifically diversity and redundancy, as students participated in interprofessional education.

Observation of participants is determined by where the researcher is situated within the activity being observed. The observer can be a complete insider or a complete outsider (Jorgenson, 1989 as cited in Creswell 2007). Additionally, Creswell states location is dynamic as the researcher can start as an outsider and then become an insider (i.e., going native). Creswell also differentiates between observation as an observer and observation as a participant. Creswell (2007) recommends Spradley (1980) as a useful resource for observations. Spradley identifies several levels of observation. These levels are on a continuum ranging from non-participation to complete participation (Table 3.3).

Table 3.3

Levels of Participation for Observations

Level of Participation	Description of Participation
Non Participation	Observing from outside research
Passive Participation	Present at the scene but not engaging with participants
Moderate Participation	Balance between insider and outsider
Active Participation	Do what the subjects are doing. Experience their experience
Complete Participation	Already an ordinary participant

Yin (2013) appears to be referring to Spradley's (1980) notion of non-participation when he discussed direct observation. The type of observation depends on where a researcher is situated within the case. I determined a priori that I would use a form of direct observation (Yin, 2013) or non-participant observation (Spradley, 1980). I did have some control over the cases because I designed the case and facilitated the sessions. However, I did not have control over how participants experienced learning with, from, and about each other during the interprofessional education. I provided the context from which the students experienced the interprofessional education and had little control, or participation, in that process.

To facilitate the direct observation, I video-recorded sessions for comparison and analysis using two Sony Handycams™ and two permanent video cameras in the simulation lab. Crabtree and Miller (1999) note that field notes "are the core of a participant observation study and the foundation for eventual analysis" (p. 62). More importantly, they note that "given that technology that currently exists, it makes little

sense to handwrite expanded accounts" (Crabtree & Miller, 1999, p. 66) and that "videotaping provide unique visual records of observations" (p. 67). Therefore, I used video-recordings to compile field notes and from these I conducted my analysis. The drawback to using video-recordings to record the field notes is that the equipment can be obtrusive (Crabtree & Miller, 1999). However, the natural environment of my cases, the simulation lab, contain many pieces of permanent technology including video-recorders. Therefore, video-recording was not obtrusive in the simulation lab. After recording was complete, I transferred video files onto a secure laptop and uploaded the files to NVivo 10^{TM} for organization and analysis. I transferred files to my supervisor using the secure University of Windsor Large File Transfer service.

Data analysis. Although Yin (2013) offers some general guidance on how to analyze case studies, he does not offer specific suggestions on how to analyze text and observation data. Therefore, I employed approaches outlined by Creswell (2007) and Crabtree and Miller (1999). Specifically, my analysis followed the Data Analysis Spiral (Figure 3.2) (Creswell, 2007) and employed an a priori codebook (Crabtree & Miller, 1999) during the initial classification stage.

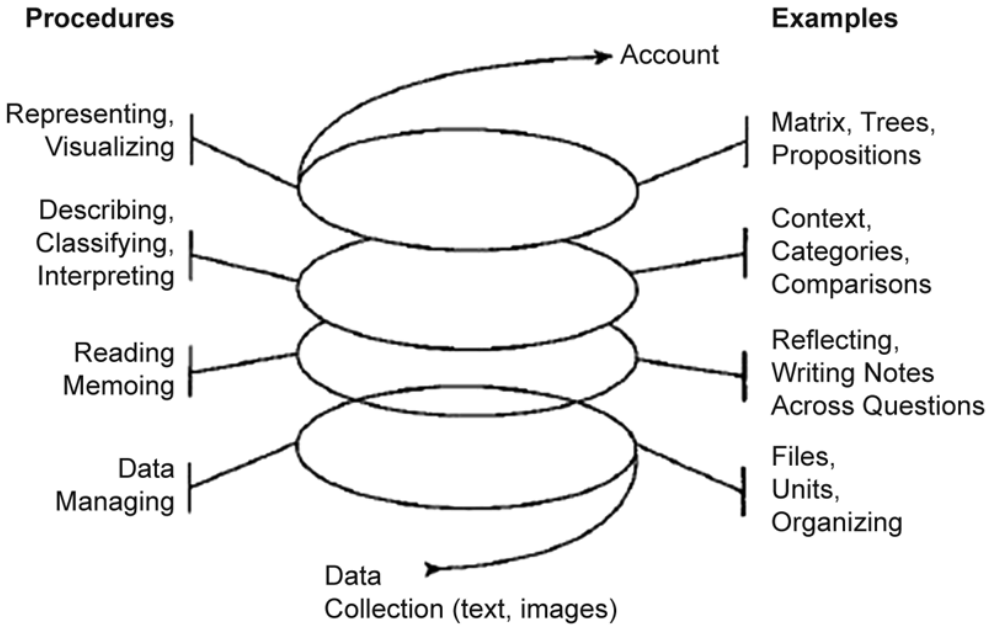

Figure 3.2[4]. Data analysis spiral. This figure illustrates the data analysis process. Reprinted from Creswell, J. W. (2007). *Qualitative inquiry and research method: Choosing among five approaches*. Thousand Oaks, CA: Sage Publications.

Immediately following the focus groups, I transcribed the audio verbatim using Express Scribe™ Transcription Software and an Infinity™ USB Foot Control. Verbatim refers to the exactness between words, but transcription contains more than written text. Little attention has been paid to transcription in qualitative research (C. Davidson, 2009; Sandelowski, 1994). Although I captured non-verbal components of the focus-groups by using a lexicon of transcription symbols (e.g., …. refers to a pause, (-) refers to inaudible conversation) and transcribed focus groups verbatim, such non-verbal components were not analyzed.

I read all focus group transcripts (96 pages) while comparing them to the audio recordings. Comparison is recommended to ensure accuracy (Morse & Field, 1995). I

[4] Copyright clearance obtained from SAGE for use of this image (License #4003370124588)

then uploaded transcripts and video-recordings to NVivo 10™ and organized the recordings and transcripts by case. Yin (2013) suggests computer software is useful for assisting with organization of large amounts of data but notes that software does not perform the analysis. As I aimed to analyze both text (i.e., focus group) and video (i.e., observation) data within cases, I chose NVivo10™ based on its ability to handle video data.

For video-recordings, I uploaded the files into NVivo 10™ and repeatedly viewed the recordings across all cases. While viewing recordings, I wrote brief accounts and keywords to act as memory triggers during more in-depth analysis. I created these notes in a journal (not in the software) as recommended by Crabtree and Miller (1999). Given that Crabtree and Miller suggest video-recordings offer an alternative to making in-depth field notes for analysis and that NVivo 10™ affords the ability to organize and categorize video data, I did not attempt to create extensive text field notes from recordings as doing so would inevitably result in losing some of the richness of the observation data.

The unit of analysis in this research is the interprofessional education session. Therefore, although I collected and analyzed data from individuals, the case was focused on the interprofessional learning of the group. Additionally, according to Yin (2009), relying on theoretical propositions to guide analysis is the most preferred strategy. Throughout data analysis I returned to my propositions to help focus attention on certain data within each case. Specifically, I used the propositions outlining concepts of complexity theory (diversity and redundancy) as a guide for how I initially deductively categorized data and subsequently inductively analyzed for themes.

I read transcripts, listened to focus groups, and viewed video-recordings repeatedly to get a sense of the entire database as recommended by Creswell (2007). During analysis, I kept a hand-written notebook where I jotted notes as memory-triggers as recommended by Crabtree and Miller (1999) and Creswell. I often returned to the notebook during subsequent analysis. Once I felt I had an in-depth understanding of the database, I moved to the classification stage and began to classify data as way to sort both the text and observation data. Classification was done within each case before moving to the next case. For focus group data, I reviewed all transcripts and coded passages of text as diversity or redundancy. For observation data, I viewed all recordings and coded in a similar fashion based on conversations or actions in the recordings. Once observation data was coded, I wrote observational notes of what was occurring in the recording to facilitate analysis for themes. Despite using diversity and redundancy as a priori codes, the processes of categorizing was an iterative process as I moved between text data, observation data, literature on diversity and redundancy, and the theoretical propositions. Once data was categorized according to codes, I was able to describe what I saw in the data according to attributes of complexity theory by looking for themes within each category within each case. Returning to the analysis spiral (Figure 3.2), I visualized data by including excerpts from focus group transcripts and narrative accounts of observations. From the analysis, I am able to offer examples of how diversity and redundancy are complementary in interprofessional education.

Issues of rigour in qualitative case studies. In this section, I discuss issues related to rigour in my case study. A discussion of rigour related to my scoping review is found directly in the methods section for the scoping review and follows Arksey and

O'Malley's (2005) steps for conducting scoping reviews. I present issues related to rigour separately for the case study because rigour is often reported separately for traditional qualitative and quantitative research designs—as opposed to scoping and systematic reviews where it is assumed in the methods by presenting the systematic and explicit steps taken by the researcher).

Morse and Field (1995), among others, have traced one of the earliest attempts to describe rigour in qualitative research to Lincoln and Guba's (1985) seminal work. Lincoln and Guba argued against using quantitative positivist approaches to establish rigour in qualitative research and introduced a set of criteria for establishing, what they called, trustworthiness. The criteria they developed, although founded on similar quantitative measures of rigour, are founded on qualitative principles. Included in the criteria are: credibility, transferability, dependability, and confirmability. Building on the work of others (e.g., Sandelowski), Morse and Field stated "measures taken to safeguard against trustworthiness are complex and that the researcher must examine them carefully before selecting those appropriate to the research in hand (p. 147). Moving forward using Lincoln and Guba, and Morse and Field, as my framework, I will address the issues of rigour used in my case study.

Credibility. Credibility in qualitative research accounts for the perspective that there are multiple truths and those truths are highly subjective (Lincoln & Guba, 1985; Morse and Field, 1995). Further, credibility refers more to the activities a researcher takes to uncover such truths as opposed to the procedures conducted to determine the truth. Lincoln and Guba (1985) suggested three activities could be used to establish credibility: prolonged engagement, persistent observation, and triangulation. Cleary the words

"prolonged" and "persistent" are debatable and must be evaluated in the context of the case study, which is what I believe Morse and Field (1995) were suggesting when they stated rigour criteria must be matched to the research in hand. Nonetheless, for prolonged engagement, Lincoln and Guba stated it was imperative researchers "spend enough time becoming oriented to the situation" (p. 302). For this research, I had worked for several years as an interprofessional education lead at the location the case studies were conducted. Likewise, I was, and still am, on the committee that advises on interprofessional education within the university where the research was conducted. I have built trust the with interprofessional community in the research setting and developed an understanding of the culture—both important aspects of credibility related to prolonged engagement (Lincoln & Guba, 1985).

Persistent observation, in the context of credibility, refers to the ability of a researcher to focus on the items that are of most importance, while overlooking those that are of little significance (Lincoln and Guba, 1985). For this research, using complexity theory, I was slightly unsure at the outset of what would be most important. That being said, using my years of experience in interprofessional education and complexity theory concepts as a guide helped focus my perspective. Therefore, the way I achieved credibility of findings using persistent observation was by merging interprofessional education practical experiences with an expanding understandings of complexity theory. Admittedly, it is difficult to know if I obtained sufficient persistent observations given my cases were short in duration. However, the length of the cases was typical of an interprofessional education activity.

Finally, triangulation is the third aspect of credibility (Lincoln & Guba, 1985). Triangulation refers to using different approaches (investigators, sources, methods and theories) to view phenomena. I used triangulation of different investigators (myself and my doctoral supervisor) initially when I was coding my data according to self-organization and emergence. In this instance, we determined the data was not credible—we could not find truth in our data that self-organization and emergence existed within interprofessional education[5]. Therefore, we readjusted our categories and proceeded with diversity and redundancy. Additionally, I used triangulation of different methods to achieve credibility by using two different data collection methods (focus group interviews and researcher observations) and reporting the findings collectively. Triangulation of methods using different modes of data collection is a common method of ensuring credibility in qualitative research (Lincoln & Guba, 1985).

Transferability. Transferability in qualitative research refers to the sufficient degree of information and description a researcher can provide from the context (setting) of their research (Lincoln & Guba, 1985). Although transferability is similar to external validity, qualitative researchers rarely know the details about the settings in which their research may be transferred to, thus, making it difficult to determine if findings could be transferred from one context to another. As such Lincoln and Guba suggest attending to transferability by providing sufficient description so that the reader of the research can determine if the setting in which they want to apply the findings is sufficiently similar to that of where the researcher was originally conducted.

[5] I will elaborate on this point in Chapter 5 and explain that my initial a priori codes of self-organization and emergence were abandoned in favour of diversity and redundancy.

Lincoln and Guba (1985) suggested providing "thick description" (p. 316) to support transferability of findings to other contexts. In my case study, I attempted to provide such thick description (within the confines of space limits); however, generalizing my findings beyond my cases is questionable. Complexity theory focuses on aspects within a system that contribute to the existence (and changes) of the overall system—many of which may not be identified. If one were to generalize my findings to another context, it would be impossible to know if the agents on the receiving end of the findings function in the same capacity, and in the same type of context, as the agents within my cases did. Therefore, although one could conceivably transfer some of my findings tentatively (perhaps in the way I have offered implications for educators in Chapter 6), transferring my findings beyond a tentative theoretical level is not advised. Such a position is supported by Yin (2013) who argued the purpose for conducting a case study is not to generalize to other populations, but to expand and generalize theories—which is what I attempted to do in my case study.

Dependability. Dependability in quantitative research refers to reliability. In qualitative research, including case study research, replication is not expected given the view of subjectivity of truth (Lincoln & Guba, 1985). In other words, replicating a study may not result in the same findings if one were studying someone's experiences and views because those experiences and views will differ across samples (and populations). Instead, Lincoln and Guba (1985) suggested keeping an audit trail of the research so that, if examined by an external source, the external source could determine the "dependability and confirmability" (p. 318) of the research.

Confirmability. Lincoln and Guba (1985) suggest confirmability refers to the quality of the data as opposed to the objectivity of the researcher. Specifically, confirmability relates to the likeness that the participants and not the researcher determined the findings from the data. Lincoln and Guba stated "the issue is no longer the investigator's characteristics but the characteristics of the data: are they or are they not *confirmable*" (p. 300). Confirmability can be achieved through triangulation and keeping an audit trail. I discussed triangulation with credibility above. An audit trail consists of areas where documentation should occur (Morse & Field, 1995). Such a trail can document researcher decisions (e.g., methodological decisions and the rationale), researcher insights (e.g., when a theme was first noticed), and subjective interpretations (e.g., what a researcher thinks is happening in the data) (Morse & Field, 1995).

Throughout all stages of my case study, I kept a notebook documenting such decisions and insights. In addition, I kept computer files with links to literature to document the rationale for certain decisions. For example, here is a quotation from an electronic note I created in January 2016 documenting insights on some of my analysis:

> The case as an enabling constraint. Case A and B referred to flow. Case C referred to fluid. Case D reported the learning 'just kinda happens'. There is something here to talk about how the learning emerges from students being provided an environment where sufficient levels of diversity and redundancy will support self-organizing behavior resulting in emergent interprofessional learning. Designing an enabling constrainer is key. Trying to capture sufficient levels of diversity and redundancy is key (but almost impossible…but perhaps can be facilitated)?

I frequently cross-referenced the handwritten notebook and the computer files and revisited them through the research process. Additionally, I created some memos within NVivo™ although I found memoing within the software cumbersome. My notebook, and computer files, as well as my data, are available for inspection by my doctoral committee should an audit be required. In Chapter 4, I present my scoping review in manuscript format, followed by Chapter 5—my qualitative findings.

CHAPTER FOUR: SCOPING REVIEW OF COMPLEXITY THEORY IN HEALTH SERVICES RESEARCH[6]

Background

There are calls to increase the use of theory when designing and conducting health services research. Knowledge translation and interprofessional collaboration are two areas of health services research experiencing such calls. Knowledge translation research is the study of how best to ensure stakeholders are made aware of, and use, research evidence in decision-making (Lapaige, 2010). Interprofessional collaboration research explores how best to support professionals to develop and maintain optimal working relationships (Thistlethwaite, 2012). Together, knowledge translation and interprofessional collaboration research hold potential for improving health care processes and outcomes (Zwarenstein & Reeves, 2006), nonetheless they share a common criticism. Researchers report low numbers of studies where authors have used theory in their research (Davies, Walker, & Grimshaw, 2010; Reeves et al., 2011) and such reports have prompted calls for improvement.

Theory is important in designing and conducting both qualitative and quantitative research on phenomena related to health services (e.g., knowledge translation, interprofessional collaboration) as it aids in the development of generalizable and robust knowledge (Rycroft-Malone, 2007; Suter et al., 2013). Explicit use of theory can assist a

[6] Chapter 4 is the outcome of a joint research undertaken in collaboration with my committee under the supervision of my supervisor. In Chapter 4, the key ideas, primary contributions, methodological design, and data analysis and interpretation were performed by the author, and the contribution of co-authors was primarily through the provision guidance and feedback on the methodological design, data analysis and interpretations, and manuscript writing.

reader to decide whether findings are applicable and useable in specific settings. Overviews identifying potentially useful theories exist in both knowledge translation and interprofessional collaboration (Graham, Tetroe, & KT Theories Research Group, 2007; Suter et al., 2013). Authors in both fields suggest that considering theoretical perspectives that include attributes of complexity theory may be useful in a study's design and data analysis (Best & Holmes, 2010; Best, Saul, & Willis, 2013; Kitson, 2009; Suter et al., 2013).

Complexity theory. Definitions of complexity theory are elusive and "there is no generally accepted statement of what complexity theory is or how complex something must be to come with the ambit of complexity theory" (Nunn, 2007, p. 378). Conceptual confusion associated with complexity theory may reflect questionable validity, transdisciplinarity (Wallis, 2008), and/or lack of in depth knowledge by researchers of the methodological considerations for complexity theory. However, the absence of a universal definition is not akin to an absence of validity. For instance, the transdisciplinary nature of complexity theory is a plausible explanation for an elusive definition because "any definition of complexity is beholden to the perspective brought to bear upon it" (Manson, 2001, p. 405). Definitions of complexity are often tailored to reflect the phenomena of interest (B. Davis et al., 2007). Despite authors using complexity theory, little is known on how to conceptualize and operationalize this theory to best suit health services research. For the purpose of this review, I align ourselves with Cilliers' (2013) description of complexity theory as a characteristic of a system. Specifically, for this review, I view complexity theory as a perspective that

conceptualizes relationships of components (i.e., individuals) within a system as the foundation from which the properties of a system emerge.

Drawing from Cilliers (2013) work, I offer some propositions of complexity theory. First, complexity theory offers a perspective to studying complex systems in a manner that does not reduce the system to individual components. From a complexity theory perspective, the interactions between components of a system are important for studying a system. Second, it is the interactions of system components that result in the overall behavior of the system. Complexity theory acknowledges that agents within a system interact to produce such behavior. Using complexity language, self-organization refers to the interactions between agents and emergence refers to the system level changes. Third, the interactions between agents are not controlled by a central control. Interactions arise from individual agents following simple rules and responding to environmental changes—control is decentralized. Fourth, the system is open to the surroundings. Interaction of the agents with their surroundings results in the exchange of information and people. These exchanges influence how those agents interact. Finally, agents have limited control over how system level changes emerge. As such, new system behavior is often unpredictable and difficult to trace back to a specific cause. These propositions, while not exhaustive, offer a general understanding of complexity theory for the purposes of our review.

Reviews of complexity theory exist in organizational science (Wallis, 2009), mathematics and management (Pollack, Adler, & Sankaran, 2014), and health care (Sturmberg, Martin, & Katerndahl, 2014). Wallis (2009) examined how complexity was used in the organizational science literature and concluded there was great diversity in

application. In turn, he called for a more explicit and comprehensive application of the concepts of complexity. Pollack et al. (2014) compared the use of complexity theory between mathematics and organizational science research. They found researchers in organizational science, although late adopters of complexity theory when compared to researchers in mathematics, are continuing to explore ways of applying complexity theory to management questions. These findings were consistent with a review by Sturmberg et al. (2014) exploring the evolution of family medicine/general practice from a complex systems perspective. Like Pollack et al., Sturmberg et al. found researchers were applying complexity theory more frequently than several decades ago. Notwithstanding, social science researchers use complexity in a metaphorical manner whereas computer science and mathematics use complexity for quantitative modeling. Across all three reviews, conclusions suggested that the "proper" or "feasible" application of complexity to social contexts remains unknown.

Researchers are increasingly incorporating complexity theory in health services research despite ongoing debate on how best to do it (Greenhalgh et al., 2010; Paley, 2007, 2010). There are no reviews exploring how complexity theory has been incorporated in the broader health services research literature related to nursing, medicine, and allied health. Given the extensiveness of how complexity theory could be conceptualized and ultimately operationalized within health services research, a scoping review of complexity theory in health services research is warranted.

The purpose of this scoping review is to explore how complexity theory has been incorporated in health services research. In doing so, I answer the following research questions:

1. What are the characteristics of studies that use complexity theory in health services research?
2. What settings and professions do researchers study using complexity theory?
3. What research questions and phenomena of interest do researchers focus on when using complexity theory?
4. How are researchers using complexity theory within health services research[7]?
5. How are researchers describing complexity theory within health services research?

Methods

I anticipated heterogeneous studies in terms of research purposes, phenomena of interest, methods, participants, and context. Likewise, although I aimed to conduct a broad, replicable, and systematic search of published literature, I did not seek to appraise and synthesize research evidence. Therefore, a systematic review was not warranted. In an evaluation of review methods, Grant and Booth (2009) described scoping reviews as "a preliminary assessment of potential size and scope of available research literature" (p. 101). Arksey and O'Malley (2005) and Levac, Colquhoun, and O'Brien (2010) have developed and advanced the recommended methodological framework for scoping reviews (Colquhoun et al., 2014). Scoping reviews involve five steps: (a) identifying the initial research question; (b) identifying the relevant studies; (c) selecting the studies; (d) charting the results; (e) collating, summarizing, and reporting the findings; and (f)

[7] The term "use" in this instance refers to how authors employed complexity theory specifically in their study. The term differs from "incorporated" which we use to refer to the broader use of complexity in health services research and to encompass all of our questions.

consulting stakeholders for knowledge translation of findings (Arksey & O'Malley, 2005). With the exception of consultation of stakeholders, I followed Arksey and O'Malley's approach, and used Levac et al. as a guide, for how to operationalize each step.

Identifying relevant studies. Literature published between inception of each database and June 2015 was collected from the following databases: The Cochrane Database of Systematic Reviews, CINAHL, EMBASE, Medline, and Web of Science. The search strategy and database selection was determined in consultation with a Master of Library Information Science (MLIS) Librarian and a researcher familiar with complexity theory. Table 4.1 outlines the search strategy for each database. Given the breadth of complexity theory, combined with a lack of agreed upon nomenclature, I anticipated literature to be indexed under a variety of terms. To account for broad indexing, we used a range of search terms often associated with complexity theory. I used citation searching from key articles.

Table 4.1

Search Strategy by Database

Database	Search Strategy
CINAHL	complexity theory OR complexity science OR complex adaptive system OR complexity thinking OR complex responsive process theory OR chaos theory
Cochrane Database of Systematic Reviews	complexity theory OR complexity science OR complex adaptive system OR complexity thinking OR chaos theory OR complex responsive process theory
EMBASE	complexity theory OR complexity science OR complex adaptive system OR complexity thinking OR chaos theory OR complex responsive process theory
Medline	complexity theory OR complexity science OR complex adaptive system OR complexity thinking OR chaos theory OR complex responsive process theory
Web of Science	TS=("complexity theory" OR "complexity science" OR "complex adaptive system" OR "complexity thinking" OR "complex responsive process theory" OR "chaos theory")

Study selection. A study was eligible for inclusion if: (a) it was published in a peer-reviewed journal, (b) it was written in English, (c) authors provided a statement somewhere in their manuscript reporting they incorporated complexity theory within their research, (d) authors studied a phenomena related to health services research, and (e) authors sampled nurses, physicians, or allied health professionals.

For *criterion c,* I did not exclude studies on the basis of study design. Articles describing quality improvement projects were excluded, but articles describing quality improvement research or research on quality improvement techniques were included. I excluded articles describing quality improvement projects because the focus

of quality improvement projects differs from that of research, with the former focused on descriptions of how a group worked to improve care for a specific population or organization and the later focused on developing new and (often) generalizable knowledge (Newhouse et al., 2006). Our focus is on complexity theory in health services *research*; thus, I excluded descriptions of quality improvement projects. Distinguishing between quality improvement and research reports is difficult (Morris & Dracup, 2007). To assist, I used criteria described by Newhouse et al. (2006) that included assessment of intent of the authors, burdens and risks to subjects, and oversight of the project.

For *criterion d*, I used the Canadian Institute of Health Research, (2014) definition of health services research. I excluded studies that used complexity theory to explain aspects of diseases (e.g., atrial fibrillation, cerebral vascular accidents). Likewise, I excluded studies offering commentary or discussion articles on how complexity theory could be used in research.

For *criterion e*, I defined allied health professionals as dietitians, occupational therapists, pharmacists, physiotherapists, and speech-language pathologists. If studies involved more than the seven professions listed above, they were included only if they focused primarily on nurses, physicians, or allied health professionals. For studies with multiple professions, when possible, I included only the results pertaining to the seven professions above. Studies were excluded if they focused solely on pre-licensure students. I had no historical date limits.

Titles and abstracts were independently screened. Articles that met inclusion criteria were then reviewed a second time using full text. If questions arose related to article eligibility, a second author reviewed the article. The second author, who is

familiar with the complexity literature, reviewed the final list of included studies. The list of articles was sent to a third party expert in the field of complexity for review. All studies were imported into and managed with bibliographic software (Zotero™).

Charting the data. Consistent with Arksey and O'Malley (Arksey & O'Malley, 2005), I extracted data related to answering our research questions. Data was entered into a Microsoft Excel spreadsheet and individual tables constructed for analysis. Data included authorship, publication year, country of research, research design, professions involved, setting of research (e.g., long term care, acute care), interprofessional focus, purpose/objective of research, attributes of complexity theory used, phenomena of interest, how complexity theory was used, and definition/description of complexity theory provided. In keeping with a scoping review approach, I did not assess the methodological quality of included studies.

Collating results. According to Arksey and O'Malley (2005), a framework should be used to collate results. I created a framework guided by our five research questions. First, I created a data table for study characteristics, including first author, year published, country, and study design. Second, I created a data table outlining the professions involved, the area of research, the setting of research, and whether the research focused on interprofessional collaboration or education. From these tables I compared characteristics, setting, and profession across all studies to answer our first two research questions. Third, I categorized studies based on their research purpose using the verb presented by the researcher(s) in their purpose statement (e.g., describe, explain, explore). While verbs may overlap when referring to research purposes (e.g., describe and explore), I categorized based on how the authors described their purpose regardless

of potential overlap to minimize subjective interpretation of purpose. I then determined each researcher's phenomena of interest. Specifically, I reviewed all research purposes and identified common phenomena of interest. This provided us with a means to categorize studies by research purpose and then compare how the phenomena of interest differed within and between each category thus answering our third research question. Fourth, I reviewed each study and identified how researchers used complexity theory in their study (e.g., conceptual framework, data analysis, interpret findings). Collectively, this approach allowed us to answer our fourth research question. Finally, I created a data table containing the description of complexity theory from each study. From this, I determined the attributes of complexity theory used by each group of authors. To organize the attributes, I followed an approach used by Wallis (Wallis, 2008) in his review of complexity in the organizational theory literature. Specifically, I extracted descriptions of the attributes (i.e., conceptual components) of complexity from the definitions and descriptions provided by the authors of the studies in our review and grouped attributes together when authors were describing the same thing. For example, I combined *relationships* and *connections* as one attribute: *relationships*. I then looked for common themes between descriptions.

Results

Figure 4.1 provides an overview of the search and retrieval results. 3478 citations were found by our search strategy. After reviewing titles and abstracts, 792 articles remained. Full text review resulted in 104 articles and after removal of duplicates (n=55) and citations searching (n=5), 44 articles were included in our review. Common reasons for study exclusion included: (a) the article was a commentary or debate on the use of

complexity theory, (b) the authors used complexity theory to describe an aspect of a disease (e.g., the neural pathway changes of Parkinson's Disease), (c) the study included participants not in our inclusion criteria (e.g., pre-licensure learners, administrators) or (d) the research focus not related to health services research (e.g., acoustic properties in rabbits within the context of hearing and speech research).

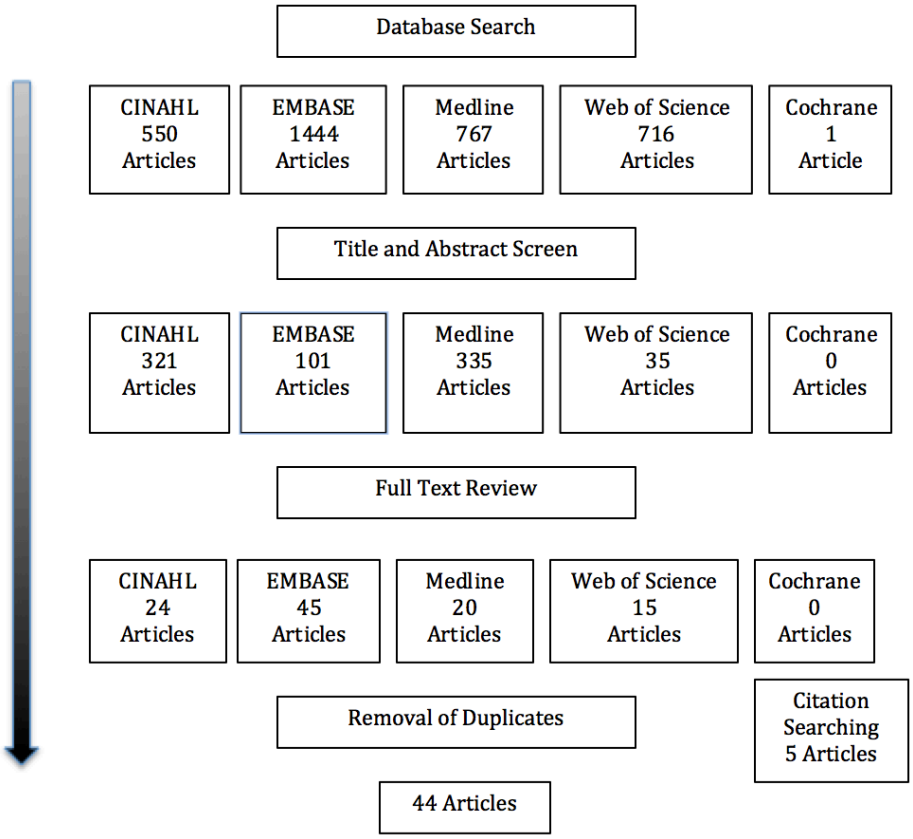

Figure 4.1: Search and retrieval results. This figure illustrates the search and retrieval process and results for all searching strategies.

Characteristics of studies using complexity theory. The general characteristics of studies incorporating complexity theory in health services research are outlined in Table 4.2. Most studies were qualitative (Aita, McIlvain, Backer, McVea, & Crabtree, 2005; Anderson et al., 2014; Brandstorp, Kirkengen, Sterud, Haugland, & Halvorsen,

2015; Brannon, Kemper, & Barry, 2009; Buttigieg, Cassar, & Scully, 2013; Colon-Emeric, Ammarell, et al., 2006; Colon-Emeric, Lekan-Rutledge, et al., 2006; Cucolo & Perroca, 2015; Eika, Dale, Espnes, & Hvalvik, 2015; Ellis, 2010, 2011; Forbes-Thompson, Leiker, & Bleich, 2007; Glenn, Stocker-Schnieder, McCune, McClelland, & King, 2014; Hilts et al., 2013; Karemere, Ribesse, Kahindo, & Macq, 2015; Lanham et al., 2009; Longo, 2007; Mash et al., 2008; Matthews & Thomas, 2007; Miller, McDaniel, Crabtree, & Stange, 2001; Piven et al., 2006; Provost, Lanham, Leykum, McDaniel, & Pugh, 2015; Rangachari, 2008; Rantz et al., 2013; Ruhe et al., 2005; Tsasis, Evans, & Owen, 2012), followed by quantitative (Anderson, Allred, & Sloan, 2003; Anderson, Corazzini, & McDaniel, 2004; Anderson, Issel, & McDaniel, 2003; Anderson & McDaniel, 1999; Colon-Emeric et al., 2013; Dickinson et al., 2014; Erdek & Pronovost, 2004; Haigh, 2008; Leykum et al., 2007; Oyeleye, Hanson, O'Connor, & Dunn, 2013; Pitkääho, Partanen, Miettinen, & Vehviläinen-Julkunen, 2015; Rantz et al., 2012; Singh, Servoss, Kalsman, Fox, & Singh, 2004; Sterns, Miller, & Allen, 2010), and, finally, to a lesser extent, mixed methods (Ellis & Howard, 2011; Essen & Lindblad, 2013; Ford, 2009). Case studies were the most common qualitative (Aita et al., 2005; Anderson et al., 2014; Brannon et al., 2009; Buttigieg et al., 2013; Colon-Emeric, Ammarell, et al., 2006; Colon-Emeric, Lekan-Rutledge, et al., 2006; Ellis, 2010, 2011; Erdek & Pronovost, 2004; Forbes-Thompson et al., 2007; Hilts et al., 2013; Karemere et al., 2015; Lanham et al., 2013; Longo, 2007; Miller et al., 2001; Piven et al., 2006; Ruhe et al., 2005) and mixed method (Ellis & Howard, 2011; Essen & Lindblad, 2013; Ford, 2009) design. Action research (Mash et al., 2008), ethnography (Eika et al., 2015), grounded theory (Lanham et al., 2009; Rangachari, 2008), and phenomenological designs (Glenn et al., 2014;

Matthews & Thomas, 2007) were used less frequently. Two authors did not identify a specific qualitative design (Rantz et al., 2013; Tsasis et al., 2012). There was a mix of designs across the quantitative studies including, in order of frequency, cross-sectional (Anderson, Allred, et al., 2003; Anderson et al., 2004; Anderson & McDaniel, 1999; Oyeleye et al., 2013; Sterns et al., 2010), randomized controlled trials (Colon-Emeric et al., 2013; Dickinson et al., 2014; Rantz et al., 2012), retrospective (Haigh, 2008; Pitkäaho et al., 2015), prospective cohort (Erdek & Pronovost, 2004), systematic review (Leykum et al., 2007), and unclear (Singh et al., 2004)

The majority of health services research conducted using complexity theory was based in the United States (Aita et al., 2005; Anderson, Allred, et al., 2003; Anderson et al., 2004, 2014; Anderson, Issel, et al., 2003; Anderson & McDaniel, 1999; Brannon et al., 2009; Colon-Emeric, Ammarell, et al., 2006; Colon-Emeric et al., 2013; Colon-Emeric, Lekan-Rutledge, et al., 2006; Dickinson et al., 2014; Erdek & Pronovost, 2004; Forbes-Thompson et al., 2007; Ford, 2009; Glenn et al., 2014; Lanham et al., 2009, 2013; Leykum et al., 2007; Miller et al., 2001; Oyeleye et al., 2013; Piven et al., 2006; Provost et al., 2015; Rangachari, 2008; Rantz et al., 2012, 2013; Ruhe et al., 2005; Singh et al., 2004; Sterns et al., 2010; Tsasis et al., 2012), followed by the United Kingdom (Ellis, 2010, 2011; Ellis & Howard, 2011; Haigh, 2008; Matthews & Thomas, 2007), Canada (Hilts et al., 2013; Tsasis et al., 2012), Norway (Brandstorp et al., 2015; Eika et al., 2015), Brazil (Cucolo & Perroca, 2015), Congo (Karemere et al., 2015), Finland (Pitkäaho et al., 2015), Italy (Longo, 2007), Malta (Buttigieg et al., 2013), South Africa (Mash et al., 2008), and Sweden (Essen & Lindblad, 2013).

Table 4.2

Study Characteristics, Application, and Attributes of Complexity Theory in Health Services Research

First Author	Year	Country	Setting	Professions Involved	Research Design	Use of Complexity Theory	Attributes of Complexity Theory Used
Aita (Aita et al., 2005)	2005	USA	Primary Care	Physicians	Qualitative – Secondary Analysis of a Comparative Case Study	Data analysis	Attractors
Anderson (Anderson & McDaniel, 1999)	1999	USA	Long Term Care	Nurses	Quantitative – Cross Sectional	Conceptual framework and interpretation of findings	Communication, Connections, Diversity
Anderson (Anderson, Allred, et al., 2003)	2003	USA	Hospital	Nurses, Pharmacists, and Physicians	Quantitative – Cross Secftional	Conceptual framework	Connections, Diversity, Feedback
Anderson (Anderson, Issel, et al., 2003)	2003	USA	Long Term Care	Nurses	Quantitative – Cross Sectional	Conceptual framework	Communication, Connections, Diversity, Self-Organization

Anderson (Anderson et al., 2004)	2004	USA	Long Term Care	Nurses	Quantitative – Cross Sectional	Conceptual framwork	Connections, Communication, Self-organization
Anderson (Anderson et al., 2014)	2014	USA	Long Term Care	Nurses	Qualitative – Comparative Case Study	Conceptual framework and interpret findings	Communication, Connections, Diversity, Emergence, Non-Linearity, Self-Organization
Brandstorp (Brandstorp et al., 2015)	2015	Norway	Primary Care	Nurses and Physicians	Qualitative – Action Research	Data analysis	Attractors, Adaptation, Emergence, Feedback, Self-Organization
Brannon (Brannon et al., 2009)	2009	USA	Long Term Care	Nurses	Qualitative – Case Study	Data analysis	Agents, Connections, Diversity, Emergence, Feedback, Self-Organization
Buttigieg (Buttigieg et al., 2013)	2013	Malta	Rehab Hospital	Physiotherapists, Occupational Therapists, Nurses, Pharmacists,	Qualitative – Case Study	Conceptual framework	Unclear

Colon-Emeric (Colon-Emeric et al., 2013)	2013	USA	Long Term Care	Nurses	Quantitative – Cluster Randomized Control Trial	Conceptual framework	Communication, Connections, Diversity, Self-Organization
Colon-Emeric (Colon-Emeric, Lekan-Rutledge, et al., 2006)	2006	USA	Long Term Care	Dieticians, Nurses, Physiotherapists, Occupational Therapists	Qualitative – Case Study	Data analysis	Adaptation, Communication, Diversity, Self-Organization
Colon-Emeric (Colon-Emeric, Ammarell, et al., 2006)	2006	USA	Long Term Care	Nurses and Physicians	Qualitative – Comparative Case Study	Conceptual framework	Connections, Communication, Diversity, Learning
Cucolo (Cucolo & Perroca, 2015)	2015	Brazil	Hospital	Nurses	Qualitative – Content Analysis	Data analysis	Unclear

Dickinson (Dickinson et al., 2014)	2014	USA	Community Health Centres and Primary Care	Physicians	Quantitative – Cluster Randomized Control Trial	Conceptual framework	Adaptation, Connections, Diversity, Learning, Reflection
Eika (Eika et al., 2015)	2015	Norway	Long Term Care	Nurses	Qualitative – Ethnography	Conceptual framework	Emergence, Learning, Self-Organization
Ellis (Ellis, 2010)	2010	United Kingdom	Primary Care	Nurse and Physicians	Qualitative – Comparative Case Study	Interpret findings	Adaptation, Agents, Co-Evolution, Self-Organization
Ellis (Ellis & Howard, 2011)	2011	United Kingdom	Primary Care	Nursing and Physicians	Mixed Methods – Case Study	Interpret findings	Agents, Co-Evolution, Emergence, Self-Organization
Ellis (Ellis, 2011)	2011	United Kingdom	Primary Care	Nursing and Physicians	Qualitative – Case Study	Interpret findings	Adaptation, Agents, Co-Evolution, Self-Organization
Erdek (Erdek & Pronovost, 2004)	2004	USA	Hospital	Nurses and Physicians	Quantitative – Prospective Cohort Study	Interpret findings	Unpredictability

Essen (Essen & Lindblad, 2013)	2013	Sweden	Rheumatology Registry	Physicians and Nurses	Mixed Methods – Case Study	Data analysis and interpret findings	Equilibrium, Emergence, Feedback, Self-Organization
Forbes-Thompson (Forbes-Thompson et al., 2007)	2007	USA	Long Term Care	Nurses	Qualitative – Case Study	Data analysis	Communication, Connections, Diversity
Ford (Ford, 2009)	2009	USA	Hospital	Nurses	Mixed Methods – Case Study	Interpret findings	Diversity, Emergence, Relationships
Glenn (Glenn et al., 2014)	2014	USA	Hospital	Nurses	Qualitative – Hermeneutic Phenomenology	Conceptual framework and interpret findings	Agents, Decentralized Control, Emergence, Feedback, Non-Linearity, Self-Organization
Haigh (Haigh, 2008)	2008	United Kingdom	Hospital	Nurses	Quantitative – Retrospective Statistical Modeling	Equation to predict changes	Attractors, Equilibrium, Non-Linearity

Hilts (Hilts et al., 2013)	2013	Canada	Primary Care	Physicians	Qualitative – Case Study	Data analysis	Communication, Emergence, Reflection
Karemere (Karemere et al., 2015)	2015	Congo	Hospitals	Physicians	Qualitative – Case Study	Data analysis	Agents, Path Depenedency, Transition Phase
Lanham (Lanham et al., 2009)	2009	USA	Primary Care	Physicians	Qualitative – Secondary Analysis Grounded Theory	Data analysis	Agents, Connections, Diversity, Emergence, Learning
Lanham (Lanham et al., 2013)	2013	USA	Hospitals and Community	Nurses	Qualitative – Case Study	Interpret findings	Connections, Learning, Self-Organization
Leykum (Leykum et al., 2007)	2007	USA	Not Applicable	Studies that would include at minimum nurses and physicians	Quantitative – Systematic Review	Classification	Co-Evolution, Connections, Learning, Self-Organization
Longo (Longo, 2007)	2007	Italy	Primary Care	Physicians	Qualitative – Case Study	Conceptual framework and interpret findings	Learning, Relationships

Mash (Mash et al., 2008)	2008	South Africa	Community Health	Nurses and Physicians	Qualitative – Action Research	Interpret findings	Emergence, Self-Organization, Relationships
Matthews (Matthews & Thomas, 2007)	2007	United Kingdom	Health Trusts	Nurses, Physicians, Pharmacists	Qualitative – Phenomenology	Conceptual framework and intertpret findings	Agents, Diversity, Emergence, Feedback, Non-Linearity, Self-Organization
Miller (Miller et al., 2001)	2001	USA	Primary Care	Nurses and Physicians	Qualitative – Comparative Case Study	Data analysis	Co-Evolution, Emergence, Self-Organization
Oyeleye (Oyeleye et al., 2013)	2013	USA	Hospital	Nurses	Quantitative – Cross-Sectional	Conceptual framework	Agents, Non-Linearity, Relationships
Pitkäaho (Pitkäaho et al., 2015)	2015	Finland	Hospital	Nurses	Quantitative – Retrospective	Conceptual framework	Feedback, Non-Linearity, Relationships
Piven (Piven et al., 2006)	2006	USA	Long Term Care	Nurses	Qualitative – Case Study	Data analaysis	Communication, Connections, Diversity
Provost (Provost et al., 2015)	2015	USA	Hospitals	Nurses, Pharmacists, Physicians	Qualitative – Field Study	Conceptual framework	Communication, Learning, Relationships

Rangachari (Rangachari, 2008)	2008	USA	Hospital	Physicians	Qualitative – Grounded Theory	Conceptual framework	Attractors, Diversity, Emergence
Rantz (Rantz et al., 2013)	2013	USA	Long Term Care	Nurses	Qualitative – Unclear	Conceptual framework and data analysis	Connnections, Communication, Emergence, Self-Organization
Rantz (Rantz et al., 2012)	2012	USA	Long Term Care	Nurses	Quantitative – Randomized Controlled Trial	Conceptual framwork	Communication, Connections, Diversity
Ruhe (Ruhe et al., 2005)	2005	USA	Primary Care	Physicians	Qualitative – Case Study	Data analysis	Communication, Connections, Diversity, Emergence, Equilibrium, Feedback
Singh (Singh et al., 2004)	2004	USA	Primary Care	Nurses and Physicians	Quantitative – Unclear	Conceptual framework	Adaptation, Central Attractors, Communication, Diversity
Sterns (Sterns et al., 2010)	2010	USA	Long Term Care	Nurses	Quantitative – Cross Sectional	Classification	Agents, Unpredictability

Tsasis (Tsasis et al., 2012)	2012	CAN	Health Care System	Nurses and Physicians	Qualitative – Unclear	Data analysis	Agents, Co-Evolution, Diversity, Emergence, Non-Linearity, Self-Organization

Note: Only the professions outlined in our elegibility criteria are reported

Settings and professions studied using complexity theory. All of the seven professions listed in our inclusion criteria were represented in our review. Authors in 70% of the studies included more than the seven professions that comprised our inclusion criteria, with management being the most common group in addition to our inclusion criteria. Studies including nursing were most frequent (82%) followed by studies including physicians (52%).

The settings studied using complexity theory consisted of long term care facilities (Anderson et al., 2004, 2014; Anderson, Issel, et al., 2003; Anderson & McDaniel, 1999; Brannon et al., 2009; Colon-Emeric, Ammarell, et al., 2006; Colon-Emeric et al., 2013; Colon-Emeric, Lekan-Rutledge, et al., 2006; Eika et al., 2015; Forbes-Thompson et al., 2007; Piven et al., 2006; Rantz et al., 2012, 2013; Sterns et al., 2010), primary care (Aita et al., 2005; Brandstorp et al., 2015; Dickinson et al., 2014; Ellis, 2010, 2011; Ellis & Howard, 2011; Hilts et al., 2013; Lanham et al., 2009; Longo, 2007; Miller et al., 2001; Ruhe et al., 2005; Singh et al., 2004), hospital (Anderson, Allred, et al., 2003; Buttigieg et al., 2013; Cucolo & Perroca, 2015; Erdek & Pronovost, 2004; Ford, 2009; Glenn et al., 2014; Haigh, 2008; Karemere et al., 2015; Lanham et al., 2013; Oyeleye et al., 2013; Pitkäaho et al., 2015; Provost et al., 2015; Rangachari, 2008), community health centres (Dickinson et al., 2014; Lanham et al., 2013; Mash et al., 2008), and other (e.g., not applicable, health care systems, health trusts) (Essen & Lindblad, 2013; Leykum et al., 2007; Matthews & Thomas, 2007; Tsasis et al., 2012). Despite most of the research being conducted with multiple professions and in settings that depend upon interprofessional collaboration, only 23% of studies used complexity theory to explicitly explore interprofessional collaboration.

Research purpose and phenomena of interest. Authors used a variety of research purposes to study an assortment of phenomena using complexity theory. See Table 4.3 for research purposes and phenomena grouping for all studies. The most common research purpose was exploratory (30%). Of these, 69% of studies listed a second purpose (to test, to describe, to develop, to examine, to identify). I further grouped exploratory studies into categories based on their phenomena of study (Table 4.3). These included interactions/relationships (e.g., participation in decision making (Anderson & McDaniel, 1999), management (e.g., management practices on staff turnover (Anderson et al., 2004), working environment (e.g., staff perspectives on caring practices (Glenn et al., 2014), and leadership (e.g., training teams (Brandstorp et al., 2015)). Two studies had two phenomena of interest based on our coding scheme (Anderson, Allred, et al., 2003; Hilts et al., 2013). Authors of one study (Anderson, Allred, et al., 2003) explicitly focused on both management and interactions/relationships and the other study (Hilts et al., 2013) explicitly focused on working conditions and change. All of the exploratory studies involving interactions/relationships focused on health professionals.

Research purposes aimed at describing phenomena were the second most common (16%). Of these, two studies (Colon-Emeric, Lekan-Rutledge, et al., 2006; Piven et al., 2006) listed a second purpose of exploring. Similar to the exploratory studies, I grouped studies based on the phenomena of interest. Similar to the exploratory studies, the majority of descriptive studies aimed to describe an aspect of interaction/relationships (e.g., describe staff behaviour in group processes (Rantz et al., 2013)) between health professionals either as a primary aim or as a combined aim with management (e.g., describe connection patterns among staff (Colon-Emeric, Lekan-

Rutledge, et al., 2006). One study described aspects solely related to management (e.g., clinical governance, management practices (Ellis, 2010) and one study described aspects solely related to work environment (e.g., describe working conditions in nursing homes (Forbes-Thompson et al., 2007).

Research purposes aimed at examining phenomena were the third most common (9%). Due to the low number of studies, I narratively report the results. The first group of authors (Aita et al., 2005) examined interactions/relationships. Specifically, they examined features of practice related to patient centeredness using a secondary analysis of qualitative data. They concluded that attributes of complexity theory assisted them in examining how patient centeredness occurs within patient and physician interactions. The second group of authors (Leykum et al., 2007) examined change. They conducted a systematic review of interventions aimed at improving Type II diabetes. The authors assigned a value to each intervention based on the degree of complexity that the intervention exhibited. The authors used the degree of complexity to examine whether interventions based on complexity attributes were more effective than interventions that were not based on complexity. They concluded that interventions with a greater number of complexity attributes were more effective for changing diabetic outcomes. The third group of authors (Sterns et al., 2010) also examined change. These authors examined the degree of culture change practice adoption. They ranked culture change practices based on their degree of complexity and examined the degree of adoption. The authors concluded that less complex practices may be easier to implement and that implementation of less complex practices may improve implementation of more complex changes. Finally, Lanham and colleagues (Lanham et al., 2013) used several attributes of

complexity theory to re-examine two studies that evaluated the spread of effective interventions. They concluded that self-organization, sense making, and interconnections could be used to facilitate the spread of effective practices.

The heterogeneity of research purposes included in the remaining studies (45%) prevented meaningful comparison. The research purposes that authors reported include advance and understand, analyze, compare, demonstrate, determine, document, estimate impact, evaluate, identify, implement, improve, produce, suggest, test hypothesis, and understand. I categorized these studies based on phenomena of interest. Change was the most common focus of studies within this category, followed by work environment, management, and, finally, interactions/relationships.

In summary, based on our analysis of research purpose and phenomena of interest, studies aimed at *exploring* and studies aimed at *describing* represent the most common research purpose of health services research incorporating complexity theory. Within these categories, complexity theory was incorporated primarily to explore or describe interactions/relationships between health care workers. There is a wide range of research purposes in the remaining studies. Within these remaining studies, the most common phenomenon of interest was change.

Table 4.3

Purpose and Phenomena of Interest

Research Purpose	Phenomena of Interest
Exploratory	Change (Ellis, 2011; Hilts et al., 2013), Leadership (Brandstorp et al., 2015) Management (Anderson, Allred, et al., 2003; Anderson et al., 2004; Mash et al., 2008) Interactions/Relationships (Anderson, Issel, et al., 2003; Anderson & McDaniel, 1999; Eika et al., 2015; Matthews & Thomas, 2007; Provost et al., 2015; Rangachari, 2008), Working environment (Glenn et al., 2014; Hilts et al., 2013; Oyeleye et al., 2013)
Describe	Interactions/Relationships (Anderson et al., 2014; Colon-Emeric, Ammarell, et al., 2006; Colon-Emeric, Lekan-Rutledge, et al., 2006; Piven et al., 2006; Rantz et al., 2013) Management(Anderson et al., 2014; Colon-Emeric, Lekan-Rutledge, et al., 2006; Ellis, 2010) Working environment (Forbes-Thompson et al., 2007)
Examine	Change (Lanham et al., 2013; Leykum et al., 2007; Sterns et al., 2010) Interactions/Relationships (Aita et al., 2005)
Combined Other Purposes	Change (Brannon et al., 2009; Dickinson et al., 2014; Ellis & Howard, 2011; Essen & Lindblad, 2013; Longo, 2007; Rantz et al., 2012; Ruhe et al., 2005; Singh et al., 2004; Tsasis et al., 2012) Management (Buttigieg et al., 2013; Ellis, 2011; Ford, 2009; Haigh, 2008) Interactions/Relationships (Colon-Emeric et al., 2013; Lanham et al., 2009; Pitkäaho et al., 2015) Working Environment (Cucolo & Perroca, 2015; Karemere et al., 2015; Miller et al., 2001; Tsasis et al., 2012)

Use of complexity theory in health services research. Researchers have used complexity theory in their research in a variety of ways (Table 4.2). The most common was as a conceptual framework applied to research approach and design (45%)[8]. Examples include using complexity theory to conceptualize variables that were subsequently operationalized to determine if attributes of complexity account for rates in staff turnover (Anderson et al., 2004), using complexity theory to conceptualize the work environment (Glenn et al., 2014), and using complexity theory to conceptualize primary care organizations (Ellis, 2010). There was variation on how explicit authors were regarding how they used complexity theory as a conceptual framework. Some authors described in detail the attributes they used and how they used them, whereas others stated that their research incorporated a complexity framework without describing which attributes or how complexity was used (e.g., Karemere et al., 2015).

The second most common use of complexity theory was as a framework for data analysis (32%). In this group, all studies were qualitative designs and the majority (57%) were case studies with authors using attributes of complexity to in data analysis. Examples of how complexity theory were used to in data analysis include comparing attributes of complexity (e.g., self-organization, emergence) across case studies (Miller et al., 2001), using complexity to "understand what I were seeing" (Aita et al., 2005, p. 303), and using complexity to code observations (Brannon et al., 2009). Again, similar to those that used complexity as a conceptual framework, authors who used complexity as a data analysis framework varied in detail regarding what they used and how they used it.

[8] The percentages in this section do not total 100% because some authors used complexity theory in multiple ways that were not mutually inclusive across categories.

Finally, the third most common use of complexity theory was as a framework for interpreting findings (29%). Examples include using complexity to illustrate leadership principles (Ford, 2009), explain clinical governance (Ellis, 2010), and hypothesize why an intervention worked to improve pain control (Erdek & Pronovost, 2004).

The remaining three studies used complexity to predict change (Haigh, 2008) or classify either interventions (Leykum et al., 2007) or culture change practices (Sterns et al., 2010). Several authors reported dual applications of complexity (e.g., (Longo, 2007) and I included both applications in our results (Table 4.2)

Descriptions of complexity theory. Authors have incorporated a wide range of attributes from complexity theory to study phenomena related to health services research. To facilitate analysis, we grouped certain attributes into categories when authors appeared to refer to the same (or similar) concept of complexity. Table 4.4 lists the referent attributes we combined and the term we used to refer to the parent attribute. Wallis (2009) used a similar approach in his review of complexity theory in organizational science. As complexity theory has no agreed upon definition and a myriad of concepts that comprise the theories subsumed within complexity theory, it was necessary to combine certain attributes to facilitate analysis. Furthermore, it is beyond the scope of this review to offer a definition of each attribute. However, readers interested in definitions/descriptions of attributes of complexity may be interested in referring to The Handbook of Systems and Complexity in Health (Sturmberg & Martin, 2013).

Overall, researchers incorporated a total of 18 attributes when referring to complexity theory (Table 4.2). All of the studies except for two (Aita et al., 2005; Erdek & Pronovost, 2004) incorporated a combination of attributes. Aita el al. (2005)

incorporated the concept of attractors to interpret secondary data and explore what is involved in patient-centered care within primary care settings. Erdeck and Pronovost (2004) introduced an intervention aimed at improving pain management that incorporated the concept of unpredictability (i.e., varying levels of certainty). Notably, in two studies, it was unclear what attributes of complexity the authors used (Buttigieg et al., 2013; Cucolo & Perroca, 2015).

A combination of three or four attributes of complexity theory was most common. The most attributes incorporated by a group of authors was six. This was done by six groups of authors (Anderson et al., 2014; Brannon et al., 2009; Glenn et al., 2014; Matthews & Thomas, 2007; Ruhe et al., 2005; Tsasis et al., 2012). Within this group, emergence was included in all studies, followed by self-organization, feedback, agents within a system, non-linearity, and diversity. The remaining attributes appeared once or twice in various combinations.

For all studies included in this review, the most common attributes of complexity theory were relationships (n=21), self-organization (n=19), diversity (n=19), emergence (n=16), communication (n=14), feedback (n=8), agents within a system (n=8), and non-linearity (n=7). Descriptions and/or definitions of the attributes varied immensely across studies and it was difficult to know for certain if authors were referring to the same concept when using the same terminology.

Although descriptions of complexity theory varied immensely across studies, it appears authors are describing complexity theory using aspects of the theory that capture how diverse relationships and communication between agents of a system can influence unpredictable changes within the system. It comes as no surprise that descriptions often

incorporate relationships, diversity, and communication. Likewise, descriptions also incorporate complexity attributes related to unpredictable changes with self-organization, emergence, and non-linearity being common in descriptions. The importance of capturing relationships and how those relationships contribute to changes in the overall system are apparent in the following examples of direct quotation of author descriptions:

> Change emerges through self-organization, defined as the mutual adjustment of behavior arising from interactions among staff as they meet immediate care demands. (Piven et al., 2006, p. 296)
>
> Complexity science suggests that organizations, such as hospitals, are complex adaptive systems. As such, a hospital is defined as a set of connected or interdependent parts or agents—including caregivers and patients—bound by a common purpose and acting on their knowledge. (Anderson, Allred, et al., 2003, p. 144)
>
> Complexity science, as related to healthcare, is the science of moving in a nonlinear and interactive manner where unpredictable outcomes are often realized; organizations are described as ever-changing collections of individuals and conditions in the organization; and patterns of interaction among individuals and connections are made in day-to-day practices among and between individuals. (Oyeleye et al., 2013, p. 537)

Despite not knowing if authors are referring to the same thin when they use similar attributes, these three quotations of authors' descriptions of complexity in health services research typify a common thread in the studies included in our review. In some cases, descriptions of complexity theory in health services research incorporate the

theory's ability to view communication and relationships between diverse agents in a system as supporting factors to overall changes of the system.

Table 4.4

Parent and Referrent Attributes

Parent Attribute	Referent Attributes
Connections	Connections, Relationships, Interconnections
Communication	Communication, Conversation, Information Flow, Information Exchange, Interactions
Learning	Learning, Sense Making, Learning Culture
Adaptation	Adaptation, System Adaptation, Innovation
Diversity	Diversity, Cognitive Diversity, Diversity of Information, Diversity of Perspective, Diversity of Views
Equilibrium	Equilibrium, Disequilibrium
Agents	Agents, Agents in a System, Input from Agents
Unpredictability	Unpredictability, Uncertainty, Levels of Certainty

Discussion

This is the first scoping review to explore how complexity theory has been incorporated into health science research. Studies incorporating complexity theory appear to be increasing in frequency. Health services researchers are primarily using complexity theory with qualitative case studies conducted in the United States focused on nursing and medicine in long-term care and primary care. Quantitative and mixed methods studies using complexity theory exist, and other settings are being studied, but both to a lesser extent. Research is primarily exploratory or descriptive in nature and aimed at understanding phenomena related to interactions/relationships and management.

Descriptions of complexity theory varied with 18 attributes of complexity theory across all studies in this review. The most common attributes were relationships, self-organization, and diversity. Descriptions appear to focus on aspects of complexity theory related to how diverse relationships and communication between individuals in a system may influence change.

There is notable consistency between our findings and existing reviews. Similar to Sturmberg et al.'s (2014) review of complexity in family medicine general practice, we found health services researchers to be expanding how they incorporate complexity theory in research. However, this expansion has largely remained at exploratory and descriptive level of research. In a review of complexity in computer science, mathematics, and management research, Pollack et al. (2014) used referencing patterns and concluded that the application of complexity theory to organizational science research using mathematical modeling techniques is uncommon. Sturmberg et al. reported similar findings in family medicine general practice. Despite 14 studies in our review being quantitative, there was minimal mathematical modeling. Although some studies in our review used modeling (e.g., Anderson & McDaniel, 1999; Haigh, 2008), mathematical modeling using complexity theory does not appear common in health services research and the use of complexity theory remains at a descriptive or exploratory level. This is not surprising since complexity theory is primarily used as an explanatory theory as opposed to predictive one (Paley & Eva, 2011).

Pollack et al. (2014) and Sturmberg et al. (2014) recommend authors move beyond metaphorical application of complexity as an observation tool. Both suggest a mathematical basis of inquiry is possible to progress complexity's application within

social sciences research. They argue a shift would enable researches to use complexity theory as a basis for quantitative modeling. Notably, neither group contends quantitative-modeling should occur without using complexity's metaphors as building blocks for conceptual frameworks; these methodological approaches are complementary and complexity is useful for each. Although we agree with Pollack et al. and Sturmberg et al., we offer cautionary advice. Our findings demonstrate variation in how authors are incorporating complexity theory in health services research with a broad range of attributes being used. Thus, we align ourselves with Greenhalgh and colleagues (Greenhalgh et al., 2010) and suggest more adaptation and refinement is needed to determine how a complexity perspective can be used to answer health services research questions. That is not to say mathematical modeling is not useful. However, forgoing foundational work and shifting methodological approaches will not progress complexity's usefulness to health services research and may only lead to more conceptual confusion. As our review suggests, there is too much variation to be certain authors are talking about, even at a metaphorical level, the same concept.

In a review of complexity in organizational science, Wallis (2008) identified 20 definitions of complex adaptive systems containing 26 different conceptual components. We found authors within our review used 18 different attributes of complexity theory. Although we used different labels than Wallis, overlap exists between common attributes used in organizational science and those used in health services research. Self-organization, agents, emergence, non-linearity, and interacting/relationships were among the most common in both reviews. Likewise, descriptions that focused on how diverse relationships and communication contributed to changes within a system are

predominant. Using the most common collective attributes as an indicator for what researchers consider the most applicable components of complexity theory within a social sciences context provides a foundation to begin to develop a better understanding of each concept and how it can be used to comprise a complexity theory perspective in health services research. Such foundational work is imperative. Many authors (e.g., Byrne, 1998; Paley, 2007; Sturmberg & Martin, 2013) agree that complexity theory offers a useful perspective to answer questions of a social nature. Likewise, descriptions of complexity theory are varied and influenced by discipline and phenomena of interest. Given complexity theory's application in health services research is relatively new compared to other fields, health services researchers have a unique opportunity to develop the foundational conceptual perspectives that complexity theory offers health services research.

B. Davis and colleagues (B. Davis et al., 2007) suggest complexity theory is not a theory but more a perspective or way of thinking about certain phenomena. They argue that the transdisciplinary nature of a complexity perspective prevents an "off the shelf" definition and application. Although the transdisciplinary nature of complexity cannot be argued, the results of our scoping review and other reviews of complexity (i.e., (Sturmberg et al., 2014; Wallis, 2008) provide a glimpse of caution that should be considered when working with complexity. Indefinable theoretical perspectives can lead to studies with unclear or missing descriptions, implicit assumptions, and absent definitions. As a result, findings from such studies are difficult to generalize with confidence. Of course, all theories, especially transdisciplinary ones, require users to assume relationships that are, perhaps, untested. Consider Rogers' innovation diffusion

theory (a transdisciplinary theory) is the most influential theoretical perspective in the knowledge translation (Estabrooks et al., 2008). However, its use in knowledge translation, specifically health, requires an untested assumption that knowledge application in health is akin to classical diffusion theory (Estabrooks, Thompson, Lovely, & Hofmeyer, 2006). Such an assumption has not limited the theory's usefulness; however, it is worth considering in the realm of complexity how many assumptions and varied definitions are tolerable.

A lack of description of how complexity is used in original research creates challenges for drawing conclusions across health services research using review methodologies (e.g., scoping, systematic, narrative). For example, we excluded several studies where authors did not explicitly state they used complexity theory in their original manuscripts. This may have resulted in research that incorporated complexity from being excluded from our review. For example, Crabtree and colleagues have conducted a longstanding program of research using complexity theory that they outlined in a 2011 publication (Crabtree et al., 2011). Such work represents a substantial contribution. However, when assessing some of Crabtree and colleagues' original studies which form the basis of the 2011 publication (i.e., Aita, McIlvain, Susman, & Crabtree, 2003; Cohen et al., 2004; Goodwin et al., 2001; Stange, Goodwin, Zyzanski, & Dietrich, 2003; Tallia, Lanham, McDaniel, & Crabtree, 2006) using our inclusion/exclusion criteria, we could not include the studies because the authors did not explicitly state they used complexity theory in the original manuscripts, they did not explicitly discuss complexity theory in their original manuscripts, and it was a subsequent publication (Crabtree et al., 2011) that identified the studies as using complexity theory. Notably, these studies were not

captured by our search strategy because they were not indexed using medical subject headings (MeSH) related to complexity nor did they have complexity as key words or titles. Consequently, they were captured by citation searching key articles located by our database searches. While such research has the potential to advance our understanding how to use complexity to answer important health services research questions, without clear and explicit descriptions of how complexity theory was used a priori in designing a study, it is difficult to know how to use complexity theory to design future studies. Notwithstanding, papers by original authors offering a retrospective look back on their program of research from a complexity theory lens are helpful (i.e., Crabtree et al., 2011; Leykum et al., 2014) but such works are difficult to integrate into reviews by other authors (e.g., this scoping review).

From this review, we stop short of recommending that complexity theory is more appropriate than other theories for incorporating into health services research. Complexity is one of many theories researchers available to health services researchers. However, the findings of our review suggest that for researchers studying factors related to relationships, communication, and diversity—specifically how these factors may contribute to change within a system—other authors have found that complexity offers an appropriate choice.

The appropriateness of complexity theory in studying systems stems from how it allows a researcher to conceptualize a system. Specifically, complexity conceptualizes a system as non-linear and dynamical. Complex systems can be understood by comparison to complicated systems. Briefly, in a complicated system, the parts that comprise the system combine in predictable, knowable ways to comprise the overall system. If one

were to conceptualize a health system as complicated, it would be possible to reduce the system and study the individual to gain an understanding of the overall system. If one studied enough components, one would know how the system works and therefore how to manipulate the system. Such an approach has fallen short when studying health systems (Kernick, 2006). Instead, complexity theory offers a toolkit (i.e., attributes) for conceptualizing and studying health systems in different manner. Complexity brings to the forefront the unpredictable nature of a complex system. Specifically, according to complexity, systems are still comprised of agents, but those agents interact with each other. The interactions of the agents are decentralized. From these interactions, changes occur within the system that may bring about additional change. One cannot trace the original cause of the change. So, while other theories offer perspectives for studying systems, many are based on the assumptions that systems behave like a complicated system, are predictable, and can be understood by studying components of a system. The reason we stop short of suggesting complexity is more appropriate than other theories for studying health services research is because health systems are comprised of both complex and complicated systems. In some instances, depending on how the researcher conceptualizes the phenomena of study, theories that assume a complicated system are appropriate. However, instances where complex systems are involved, such as understanding how change may influence organizational culture, complexity theory offers an appropriate perspective.

Complexity theory is similar to other theories useful in health services research—especially theories aimed at exploring relationships in systems. Two such theories are systems theory and social network theory. Authors identify systems theory as being

closely related to complexity theory (B. Davis & Sumara, 2006; Phelan, 1999; Richardson & Midgley, 2007). Similar to complexity, systems theory also seeks to understand how relationships between agents of a system influence change. However, according to Phelan (1999), systems theory is focused on identifying and optimizing relationship characteristics whereas complexity is focused on understanding what influences interactions so that conditions may be created to support further interactions. In essence, complexity is more exploratory whereas systems theory is more confirmatory (Phelan, 1999). Social network theory offers a perspective of how relationships between individuals can influence the spread of something (e.g., information, disease, innovation) within networks (Granovetter, 1983; Kadushin, 2012). Using social network theory, researchers can map detailed relationships between entities for the purposes of describing and predicting how network structure may influence an outcome. In essence, the focus in social network theory is the connection of agents within a system. While complexity theory also offers a perspective on connections between agents, the focus of complexity takes a less reductionist view on interactions than social network theory. Clearly systems theory, social network theory, and many other theories are appropriate for health services research. A choice of theory depends on multiple perspectives. As such, we stop short of suggesting complexity theory is more appropriate than other theories align ourselves with B. Davis and Sumara (B. Davis & Sumara, 2006) to suggest complexity does not rise over other theories but instead rises among them.

Variation across studies on how complexity is incorporated is expected. It is a product of intellectual grappling, experimentation, and exploration on how a complexity perspective can be incorporated to answer health services research questions. In a sense,

the findings of this scoping review represent evidence that the foundational work that so many authors urge is occurring. Although we are unable to determine what is appropriate use of complexity theory in health services research, the appropriateness of variation in the early stages of complexity applied to health services research is an expected finding of this scoping review

Limitations

There are several limitations in our review. First, related to our search strategy, we acknowledge that not all authors will agree our search terms are integral with elements of complexity theory. We felt it necessary to take an approach of broadness during study identification, keeping with Arksey and O'Malley's (2005) framework for scoping reviews. Second, this scoping review was conducted as part of a doctoral dissertation. As such, it was conducted primarily independently (with a second reviewer when needed) and, therefore, did not benefit from a team approach to scoping methodology (see, for example, Daudt, van Mossel, & Scott, 2013; Levac et al., 2010). A solitary approach has been used in scoping reviews by other doctoral candidates (e.g., (Colquhoun, Letts, Law, MacDermid, & Missiuna, 2010), however; the results would be strengthened by a team of reviewers. Third, we included only studies published in English. The effect of inclusion and exclusion in systematic reviews by language is inconclusive (Garg, Hackam, & Tonelli, 2008), yet there is a possibility of excluding important studies from our scoping review - most likely related to the country of research origin.

Conclusion

Researchers are incorporating complexity theory in health services research. Researchers using complexity theory in health services research are primarily using the theory for various aspects of qualitative case studies (e.g., conceptual framework for study design, framework for data analysis) involving nursing and medicine in long-term care and primary care. Research is at the exploratory or descriptive level and focused on interactions/relationships and management. Authors have employed many attributes of complexity and descriptions often incorporate aspects of complexity theory related to how diverse relationships and communication between individuals in a system can influence change.

The overarching theme from this scoping review is variation. Although variation may be thought of as a drawback, variation may also be a product of applying a novel and malleable theory in a new context. We do not yet know how best to incorporate complexity to study phenomena in health services research and the debate is far reaching. Perhaps there is no one method to apply this theory and its malleability permits broad application? That said, authors are attempting to study important phenomena using complexity theory and are grappling with how to use this theory. Although complexity theory shows promise in health services research and health services delivery, conceptual confusion and inconsistent application hinders the operationalization of this potentially important perspective. Complexity appears particularly applicable for studying relationships and interactions between health professionals and management. However, generalizability from studies that use complexity theory, at present, is difficult due to heterogeneity and variation in reporting. Future research should include clear definitions

and descriptions of complexity and how it was used in studies. In summary, more research, debate, and exploration are still needed to continue to understand how complexity theory can be incorporated in health services research.

CHAPTER FIVE: QUALITATIVE FINDINGS

Background

I used an a priori codebook (Crabtree & Miller, 1999) to code and organize data, and, thus, demonstrate how complexity theory could be used to understand and possibly support interprofessional education. The concepts I originally chose for a priori codes were *self-organization* and *emergence*. I chose these concepts based on results from a scoping review of complexity theory in health services research (Thompson et al., 2016) and extensive reading on complexity theory. As I coded and analyzed my data, after the data was collected, I determined these concepts were not sufficiently present throughout the data—in some instance I captured possible self-organization and emergence (and I identify them throughout my findings), but it was difficult to be certain and occurrences were seldom.

Investigator triangulation (i.e., different evaluators reviewing the same data) with my supervisor helped to confirm the apparent disconnection between the collection methods, the data, and the concepts. Data triangulation is a method of establishing validity (Yin, 2013), or what Lincoln and Guba (1985) refer to as credibility and confirmability (which I discussed in detail in Chapter 3—The Methods). I could not conclude the concepts were absent from my data—such concepts are important components of interprofessional learning (McMurtry et al., 2016; Weaver et al., 2011). However, how they may have appeared within the data and the relatively short duration of data collection made it difficult, if not impossible, to use self-organization and emergence as a priori codes. In the language of Lincoln and Guba, the findings were not credible or confirmable using self-organization and emergence as a priori codes.

An explanation for why self-organization and emergence were not detected in my data relates to both the duration of the experience being studied and the duration of data collection. Authors of qualitative studies have identified instances of self-organization and/or emergence in the past using similar methods as me. However, in past instances, either the data collection or the experience of the participants (or both) occurred over a longer duration than in my research. For example, in a post hoc analysis of qualitative data obtained from teacher development cases, Fazio and Gallagher (2009) were able to identify emergent and self-organization qualities in their data. However, their two cases occurred over the course of 1 year and 2 years respectively, and the data collection followed a similar longitudinal trajectory. Related specifically to interprofessional education, Weaver et al. (2011) identified self-organization and emergence within data collected using focus groups with interprofessional educator course developers. Again, similar to Fazio and Gallagher, the participants were involved in an activity over the course of 9 months. Finally, in a multiple case study of four nursing homes, Colon-Emeric et al. (2006) collected field data by way of observations and interviews over the course of 6 weeks. They determined the degree of self-organization within a nursing home either impeded or facilitated care planning for residents. In all of these cases the length of the experience being studied and/or the data collection occurred over months and years as opposed to hours. In my research, both the experience and data collection occurred over 3 hours. Therefore, it is possible self-organization and emergence were not observed in my data due to the relatively short experience and data collection periods.

Through discussions with my supervisor, consideration of scoping review findings (Thompson et al., 2016), continued reading on complexity theory, and re-

examination of the data, I shifted my focus to concepts of complexity theory that we (my supervisor and I) thought would be more detectable with our methods (case study research using focus group and researcher observation data). More importantly, I shifted my focus to concepts of complexity theory that could potentially vary between cases. A complex system or phenomenon could not have "too much" or "too little" self-organization or emergence. Likewise, self-organization and emergence do not vary in a way that could be directly altered or supported by an educator. Therefore, I shifted my focus to concepts of complexity theory that could be observed and that an educator could support when designing and implementing interprofessional education.

B. Davis and Simmt (2003) suggested complexity theory provides researchers (and educators) a way of moving beyond descriptive studies. Complexity theory offers a means for identifying what is happening in a complex learning system and determining how it could be made to happen again (B. Davis & Simmt, 2003). Further, B. Davis and Simmt identified several aspects of complexity theory as being necessary for complex learning systems to learn—two of which are *internal diversity* and *redundancy*. Diversity was the second most common concept of complexity theory used by health services researchers (Thompson et al., 2016). Although redundancy was not as common in health services research—primarily because it was not a term used by authors of studies included in the review—redundancy enables, among other things, communications between agents (i.e., learners) in a system (B. Davis & Simmt, 2003). Communication was the fourth common concept of complexity theory used by health services researchers (Thompson et al., 2016). Moving forward, I shifted my focus from self-organization and emergence to diversity and redundancy as the codes for my a priori codebook. Diversity

and redundancy enable and constrain broader concepts such as self-organization and emergence (B. Davis & Simmt, 2003) (Table 5.1). Further, in my research, I used diversity and redundancy in a manner consistent with complexity theory and specific to how these two factors exist within a complex system. A more thorough discussion of diversity and redundancy, and their location within the broader complexity literature and the interprofessional education literature, is found in Chapter 2 (The Literature Review).

Table 5.1

Two Coding Concept Definitions

	Diversity	Redundancy
Definition	Diversity refers to the different ways that learners contribute to learning with, from, and about each other (thus capturing individual and group learning). Diversity of agents within a system contributes to the overall intelligence of that system.	Redundancy refers to sameness of learners within the group and how that sameness contributes to learning with, from, and about each other by facilitating interaction and gap-filling within the group. Sameness may refer to many characteristics such language, perspective, experiences, etc.

Organization of Findings

I organize the findings broadly by case (i.e., Case A, Case B, Case C, and Case D) and then within each case more specifically by diversity and redundancy. Adhering to space limitations, I present one theme per case for both diversity and redundancy. However, some cases had more than one theme. For example, Case A has multiple themes for diversity and redundancy. Additionally, some themes appeared in more than one case. For example, *diversity as a foundation for interprofessional learning* appeared in Case A and Case C. Furthermore, *redundancy as a contributor to flow* appeared in Case A, Case C, and Case D.

I present two types of data to support the themes within each case. I offer verbatim quotations from the focus groups with my interpretations of each. Verbatim quotations are denoted using a letter followed by a number (e.g., B3), which corresponds to the case and participant number and can be used to cross-reference transcribed data. Researcher observation notes are included and are denoted by an RO immediately following the text

Characteristics of Cases

My research included four cases. The cases occurred during March and April of 2015 on a medium sized university campus. Cases occurred at the end of the winter semester and prior to the winter exam period. All cases were comprised of undergraduate students. Case sizes ranged between 3 and 5 students. Recruitment was aimed at undergraduates in kinesiology, medicine, nursing, psychology, and social work. All professions were represented except medicine because no medical students volunteered. All cases except Case A included female and male students with female students being the predominant participant. Given that nursing represented the most predominant profession, it was expected that female participants would be most common. All cases had a mix of junior (first two years of a program) and senior students (final two years of a program). Table 5.2 outlines the key themes I elaborate on in the findings, Table 5.3 outlines the themes within each case and, and Table 5.4 outlines the demographics of each case.

Table 5.2

Themes Elaborated on in the Findings

	Diversity Theme	Redundancy Theme
Case A	Diversity as a Foundation for Interprofessional Learning	Redundancy as a Contributor to Flow
Case B	Diversity as a Disrupter to Flow	Redundancy as a Connector within Interprofessional Education
Case C	Diversity as a Foundation for Interprofessional Learning	Redundancy as a Contributor to Flow
Case D	Diversity through Interaction	Redundancy as a Contributor to Flow

5.3

Themes within each case

	Case A	Case B	Case C	Case D
Diversity	Diversity as a Learner Expectation	Diversity as a Way to Learn Roles	Diversity as a Foundation for Interprofessional Learning	Diversity Through Interaction
	Diversity as a Foundation for Interprofessional Learning	Diversity as a Disrupter to Flow		
	Diversity as a Multifaceted Component of Interprofessional Education			
Redundancy	Redundancy as a Contributor to Flow	Redundancy as a Connector within Interprofessional Education	Redundancy as a Contributor to Flow	Redundancy as a Contributor to Flow
	Redundancy as Overlap		Redundancy as an Equalizer Between Students	Redundancy as Overlap

Table 5.4

Case Demographics

Category	Case A	Case B	Case C	Case D
Sex				
Female	3	2	3	4
Male	0	1	1	1
Level				
Junior	1	1	3	1
Senior	2	2	1	4
Program				
Kinesiology	1	1	1	1[a]
Medicine	0	0	0	0
Nursing	2	2	2	3
Psychology	0	0	0	2
Social Work	1[a]	1[a]	1	0
Total Present	3	3	4	5

[a] Joined the research but did not attend the simulation. I report these numbers to illustrate how the simulations/case composition was intended to ensure an assortment of professions participating in the interprofessional education activity.

Note. Students were classified as junior if they were in the first two years of a program and senior if they were in the last two years of the program.

Case A: Diversity

Diversity occurred within Case A in three ways: diversity as a learner expectation, diversity as a foundation for interprofessional learning, and diversity as a multifaceted component of interprofessional education. In the interest of space, I discuss diversity as a foundation for interprofessional learning because it was the most prominent theme represented by the most data.

Diversity as a foundation for interprofessional learning. Diversity contributed as a foundation for interprofessional learning within Case A. Students identified the *learning from* component of interprofessional education as stemming from diversity as illustrated by the following quotation:

> *Also the education piece of that, so hopefully no one profession is coming in and saying: "I know everything there is to know about this". Keeping yourself open to learning from other people, and recognizing that they know things you don't know.... and that you can learn something from other people and from other professions...that's what I think about (A1).*

This was echoed in another student's response when she described the informal aspects of interprofessional education:

> *It's not like anything specific about a patient or anything but we will just like throw ideas out there and talk about stuff and you just like see how the different, like professions connect together and how they fit together and like what her place is and what her place would be in a specific situation (A3).*

In the above quotations, the students suggested diversity within the group created an opportunity to explore and compare ideas from different professions. One student

described an increase in the level and amount of professional diversity as being an asset to effective interprofessional education:

> *Lots of different professions. Like, and that's maybe hard to achieve in [city where the research occurred] but I would definitely go to a speed dating, other professions, but professions like really, that I, you would almost never interact with. Like, an x-ray tech. Lots of diversity. Thinking outside the box (A1).*

Diversity was a common element in the focus group data. Students spoke about how they valued, interacted with, and navigated diversity. They acknowledged that diversity was necessary for interprofessional learning—a foundation for interprofessional learning. Educators charged with designing and implementing interprofessional education opportunities must create the spaces for students to encounter and explore diversity and even anticipate the self-organization and emergence that diversity undoubtedly supports. It is evident in the three quotations above that students expected to keep themselves open, throw ideas out there, and engage with diverse professions in the process. From these quotations, the simulation created sufficient boundaries to orient student interactions yet provided enough openness to permit varied responses (B. Davis & Sumara, 2006). In the context of complexity, the diversity within this case is a concept that is relational to other concepts, such as redundancy, self-organization, and emergence that collectively characterize a complex system. More specifically, diversity within the complex system that is interprofessional education, or in Case A, is an attribute that acts as a foundation to learning. Viewing diversity as a concept within a broader theory makes it necessary to consider the other attributes of the theory simultaneously—that is diversity exists in

conjunction with redundancy, self-organization, and emergence within interprofessional education and cannot be examined in isolation.

Diversity as a foundation for learning was also evident during the simulation and post-simulation discussions. The following researcher observation during the pre-simulation session when students were working through the case initially and developing a plan for interacting with the simulation highlights how diversity acted as a foundation for learning:

> *During the pre-simulation, the students are discussing what they think are the key priorities for the patient prior to entering the simulator and interacting with the patient. The students have individually reviewed the patient's case and are working through a series of questions designed to prepare them for interaction with the simulated patient. The students have met each other approximately 30 minutes earlier. Immediately and un-provoked, the students begin by talking about priorities from the perspective of their own profession and use phrases "from my perspective" (8:15) and "would somewhat be my role" (8:22). Students were not explicitly instructed to approach the case from the perspective of their own profession. The discussion begins by students going around the table with everyone sharing their priorities. For example, after sharing several priorities, it is common for students to signify the end of their priorities using phrases such as: "how about you guys" (9:45) or glancing at another student. Each student shares one or two priorities and then moves on to the next student. There is limited discussion and none of the priorities are the same. Instead, students seem to value the importance of sharing a variety of priorities based on*

their professional perspective and doing so in a democratic fashion. However, once everyone has their turn to share a few priorities, the discussion then shifts with students elaborating on priorities offered by other students (this is also explained by redundancy). The discussion clearly has two parts: the initial individual sharing of priorities based on professional perspectives followed by the flowing discussion where priorities are elaborated on using professional perspectives. Collectively, this process leads to students compiling a list of overall priorities. This list is a mixture of profession specific priorities and represents, in the students' view, the most important priorities for the patient (RO).

During this interaction, students inherently located the importance of "patient priorities" within their professional context. In other words, students identified priorities they believed represented the priorities from their professional perspectives. Interestingly, no student shared a priority that was raised by another student. They may have identified identical priorities but did not verbally share such priorities and instead focused on the different priorities across professions. Diversity across professional boundaries appeared to support such a discussion. Students assumed the perspective of their profession to identify priorities initially. Furthermore, diversity appeared to promote further discussion (and perhaps learning) amongst students about their profession-specific priorities. Students were able to acknowledge and build upon their diversity and it appeared they valued the importance of diversity during such a discussion as they ensured each person had a turn to share the priorities they believed were of most concern from their professional perspective. There was little discussion and students appeared to be learning from and about each other as opposed to only with each other. However, once everyone

had shared, the discussion seemed to shift. It was still focused on priorities; however, students seemed to shift focus to elaborating on and adding to priorities that others had shared. For example, the following researcher observation:

> *The students are identifying priorities for the patient. It is about 13 minutes into the discussion and each student has had an opportunity to share what he or she believes to be the most important priorities. However, the students do not appear to feel the priority list is complete as the group is now identifying additional priorities but they appear to be doing so collectively as opposed to individually ~ these are shared priorities. Likewise, the priorities they are identifying at this stage seem to be stemming from priorities identified in their earlier discussion. For example, one student is discussing the need for a home assessment to ensure the patient's environment is safe for him to be discharged (13:10). She mentions that the patient has family to assist and states "like what you said [pointing at another student…it's his interpretation of how the family feels and there really is no interpretation of how the family really feels" (13:25). As the student is saying this, the third student is nodding and saying, "yes, yes." The third student then adds: "yes, and that is why we need a social worker or someone along those lines to work on that piece" (13:42). The third student then elaborates, "even with a home assessment, simple things…he's already had one fall so he's at risk for more falls, so simple things like area-rugs, clutter, and like you said [pointing at the original student]." The students continue on for several minutes adding to the priority list and tweaking existing priorities (RO).*

In the above researcher observation, it appears students were benefiting from both diversity and redundancy through discussion and elaboration. Compared to the first example, which highlighted how the process began, students later seemed to learn with each other (in addition to from and about*)*. The emphasis no longer seemed to be on sharing different priorities (diversity) and more so about elaborating on existing priorities from their professional perspectives (redundancy). The complementary nature of diversity and redundancy is apparent and resulted in a free-flowing discussion where diverse perspectives were welcomed, elaborated on, and refined to create a final collective of patient priorities. It could be said that self-organization of students was supported by diversity and redundancy and ultimately produced discussion/learning that emerged in a relatively unpredictable manner. Although not completely unpredictable, because the students were guided to devise priorities, the types of priorities and ensuing conversations that lead to additional priorities were unpredictable. These findings are aligned with findings in the focus group section where students spoke about assembling a puzzle or throwing things out there. It appears there was a sufficient balance of diversity (and redundancy) in addition to rules and flexibility to sustain a discussion for putting the pieces of a patient's care together, resulting in interprofessional learning within an interprofessional context. Within Case A, diversity acted as a foundation for interprofessional learning when viewed through a complexity theory lens.

Summary of Case A diversity. Diversity played a role in interprofessional learning in Case A in three ways: diversity as a learner expectation, diversity as a foundation for interprofessional learning, and diversity as a multifaceted component of interprofessional education. In the following section, I illustrate how redundancy was an

equally important concept when using the lens of complexity theory to explore interprofessional learning within interprofessional education.

Case A: Redundancy

Redundancy is complementary (not oppositional) to diversity and benefits learning in two ways: facilitation of interaction and compensation for gaps. Redundancy in Case A appeared in two ways, which are similar to the benefits outlined above: redundancy as a contributor to flow and redundancy as overlap. In the interest of space, I present redundancy as a contributor to flow. I present this theme because it was common across several cases. Further, redundancy as a contributor to flow is closely aligned with complexity theory (perhaps more so than redundancy as overlap) and may be a factor that potentially contributes to self-organization and emergence.

Redundancy as a contributor to flow. During the focus group, students shared that they felt the conversation between themselves and the patient "flowed well." The following conversation between all three students and the researcher highlights this point:

> *Just on my own, like I felt my own comfort level so at first you know you are a little bit anxious and you are kind of thinking, like, oh, am I going to hit the right points, but then, um, we were able to laugh a bit with him and...(A1).*
>
> *And it just kind of flows (A2).*
>
> *Ya! Like I thought it flowed well and well he...(A1).*
>
> *When you say flow, what do you mean flow (Researcher).*
>
> *Just, um, there were no awkward pauses where we were shuffling through our papers and he's like, well, what are you doing? What's happening next? Everybody's responses were kind of natural and…(A1).*

It was like a conversation (A3).

It really...it wasn't a forced…interaction really. I think it was a little more comfortable and we were able to deal with situations like where he asked about his dressing and we took a look at it. That was unexpected...like we didn't go in there thinking we were going to look at his dressing but we did and like we kind of handled it as best we could and even that was fine (A1).

In the above excerpt, all students seemed to agree that their interactions during the interprofessional simulation resembled a natural conversation. They seemed surprised at the natural flow of the conversation. Despite diversity, there was a sufficient level of redundancy in the conversation to support flowing interaction. Turning to complexity theory, there were sufficient levels of diversity and redundancy occurring simultaneously to allow the agents (i.e., students) to experience a flowing conversation. Students appeared to self-organize based on their actions with each other and their interactions with the environment (i.e., simulator and the other students). As a result, their conversations emerged as a natural flowing conversation. Recall, interprofessional education is about learning with, from, and about each other and, thus, depends on an emergent conversation between participants.

In some instances, redundancy occurred between some, but not all, learners, and this affected the flow of the conversation. The following researcher observation illustrates how learners may have experienced redundancy differently:

Students are now working to organize their priorities list into short and long term goals. It is about 29 minutes into the pre-simulation. The two senior students have spoken more than the junior student. The junior student raises the point that it is

important for the team to "figure out a way that he could still do his activities" (29:07). She is referring to the fact that the patient enjoyed many activities prior to his fractured hip that may now be difficult for him to enjoy. One of the senior students, from a different profession than the junior student, then adds to her point and they begin discussing aids that the patient may use to still enjoy his activities. For example, they begin to discuss modifications for curling that he could use. The other senior student does not seem convinced and immediately moves the conversation to other priorities (RO).

In the above example, there appeared to be a sufficient level of redundancy between the senior and junior students who are discussing the modifications. They both seemed interested, and knowledgeable, in identifying aids for the patient so that he can still continue to enjoy specific activities. However, the other student, although likely interested in helping the patient remain active, appeared hesitant. Hesitancy could be a result of too much diversity and/or not enough redundancy of knowledge related to aids for activities. The following quotations from the focus group on the same observation highlight how the flow of the conversation influenced interprofessional learning. The senior nursing student noted:

This might be a really minor thing but I, I think I really, ((laughing)), I learned that when we talked about curling, and, in my own head I just maybe…"well, he's never going to curl again". Like it's not, clearly not safe for him to curl. He's going to be on the ice and he's going to be unstable and bla bla bla. So, for, you ((kinesiology student)) to say, "you know there are adaptive devices for curling and you can use the stick and I think we can get you back to

that"…that was a bit of a…ohh, okay, well I didn't, maybe I don't know enough about curling, or, like, I don't know…I just, the sort of snap judgment (A1).

The junior nursing student later raised a point:

Can I just, so like we are both in nursing but just like seeing you snap to, "oh, you can't curl anymore" whereas I was kind of like "maybe there is a way" just like, seeing like the different ways that like we think even though we are in the same, like profession, right, like, because people always like, "nurses they think this way, they think this way" but like, we were still thinking like differently right, and I think a lot of what we bring to the table comes from our life experiences (A2).

The senior nursing student responded:

That's a good learning piece for me even from the situation is, ya, like, not to, I guess I'm going through a checklist in my head and that kind of thing and just being, being sure the things on the checklist are actually right ((laughing)). Before, like you know, before you present them to the patient. Because I think that happens a lot…and I've seen that happen a lot where, you just sort of, you throw things out without thinking too much without, where's that person going to take that. Like if I tell you we're going to cut your leg off, I don't have a lot of background for knowing what that means to you so you need to maybe step back a little bit and think what's the impact me saying this seemingly innocuous thing like "you're never going to curl again", what does that mean to you as a patient (A1).

In these quotations, one can see how sufficient diversity was important and how it may have supported students to learn with, from, and about each other during interprofessional education—with reference again to "throwing things out there" and the notion that students were observing and analyzing/comparing how the others were responding. Further, in this example, redundancy allowed for the junior nursing student and senior kinesiology student to move the conversation (and perhaps the learning) in a direction that was unfamiliar to the senior nursing student. Without such redundancy, the conversation likely would not have emerged in the direction it did. The following quotation illustrates how redundancy contributed to flow within the simulation. When asked about the learning within the interprofessional education simulation, one student reported:

> *I think it really just kind of emerged, like, if I said one thing I'm sure it sparked an idea in someone else's head and that's where it kind of went from and it just kept going it seemed and even if we started with a question, we would sometimes end up in left field but it's because you say one thing which sparks another thing which sparked another thing…so I think it just kind of unfolded that way (A3).*

In this quotation, a sufficient level of redundancy was balanced with a sufficient level of diversity to facilitate interprofessional learning. There was enough redundancy to facilitate "sparking of ideas" between learners, yet enough diversity to elaborate on those ideas and develop new ideas. Through these sparks and elaboration, the conversation self-organized around a topic and learning emerged.

Summary of Case A redundancy. Redundancy was useful for exploring interprofessional education in Case A. Redundancy related to redundancy as a contributor

to flow and redundancy as overlap. These themes are similar to the benefits of redundancy related to facilitating interaction and compensation for gaps.

Case B: Diversity

In Case B, diversity related to diversity as a means of learning different roles and diversity as a disrupter to flow. In the interest of space, I will discuss diversity as a disrupter to flow. I chose diversity as a disrupter to flow because it complements the theme related to redundancy (redundancy as a connector) and the overall applicability to complexity theory.

Diversity as a disruptor to flow. The conversations throughout Case B were often choppy and did not appear to flow. Individual contributions to the discussion did not lead to further discussion and instead emerged as a series of single contributions. For example, during the simulation, students in Case B did not enter into any sustained dialogue related to priorities. Individually, they shared their perspectives on priorities, but it emerged more as a list-making exercise as opposed to an exploratory discussion—priorities were rarely elaborated on. The following researcher observation illustrates the lack of flow:

> *Students are approximately 9 minutes into the pre-simulation. They are listing priorities for the patient. One student shares a priority related to home modifications that may be required. Another student immediately suggests that the patient can't afford those modifications. The first student then adds that if he (the patient) can't afford it he may need alternative living arraignments. This results in no further discussion and all students looking down at their papers. The original student then raises a question of finding out where he lives. After the*

facilitator (researcher) reveals where he lives, another student suggests that when he is discharged he will need to pay for ambulance transfer. The third student does not speak during pre-simulation unless asked a question directly. The conversation is not flowing and requires constant facilitation. Students repeatedly ask the facilitator (researcher) for information (RO).

The above researcher observation is representative of how students in Case B developed their list of priorities and interacted throughout the case. A lack of sustained dialogue resulted in a "choppy" discussion and could be a result of many factors. Turning to complexity theory, specifically diversity, there may have been too much diversity and too little redundancy related to the topics discussed. For example, in the above researcher observation, the student who was mostly silent during the pre-simulation may not have had the same knowledge and therefore found it difficult to engage in the discussion. Likewise, too much diversity between all learners, and too little redundancy, may have prevented the entire group of learners from self-organizing in a manner that supported interprofessional learning to emerge. The following dialogue supports the notion of too much diversity with too little redundancy: "I found it weird because of (a) the simulation and (b) I was worried because we all have different personality types we would just be contradicting each other" (B3). A second student added to this idea: "I think it went well considering. It was weird talking to a mannequin…never had to talk to a patient in general" (B2). Finally, a third students stated: "Like I've never talked to a sim doll before however, those things, like, I've been around so much they just don't phase me" (B1).

During the simulation, each student took a turn to address a specific area that was predetermined during the pre-simulation. Interestingly, despite a choppy appearance, students reported a generally positive experience:

> *I think what controlled the learning most was, ah, our area of topic. I was, like, I don't think I really got the point that I was trying to get across but like, I'm really quite used to them so, like when we walked in, I started the conversation then we all kind of…once I started the conversation like with the sim doll and then introduced people…the others interact with the doll afterwards…nutrition it's not really, like, we don't really go hugely in depth in the nursing so like as soon as that came up (.) took control and that's how I think the flow of learning went with the area of strengths (B1).*

The above quotation supports the observation that students took turns addressing areas of expertise but suggests they did experience some flow to the conversation—however, as noted in the quotation, the students seemed to expect a "turn-taking" approach to the simulation as opposed to a flowing dialogue. The other two students agreed:

> *Because everything (is) interconnected so when she is talking about the psychological and then Mr. Sampson said that he was worried about the dressings, his care, then (.) took over and then when he was talking about the nutrition then I took over and then talked about the exercise and then it just kind of went together (B3).*
>
> *Once you got into one topic it kind of lead to like the other, like even like getting into like keeping active there's the psychological aspect of it, there's the 'what he can do' and the keeping his pain under control (B2).*

The latter quotation suggests diversity supported some flow to the students' thinking about the case but outwardly those conversations were choppy. The student's mentioning of things being "interconnected" is akin to redundancy in a complex system. That is, conceptually, students were able to manage their diversity by relating back to the patient and identifying connections between their contributions. Using complexity theory to interpret these findings, one can conceptualize the flow of conversation as being self-organizing as the topics would stem from other topics with no student having an overarching plan of where the conversation would lead. There was sufficient diversity to support creativity with enough redundancy for commonalities. However, because students in Case B did not often act upon the interconnections, the interactions appeared choppy from a direct observation standpoint.

Summary of Case B diversity. Diversity within Case B related to diversity as a mean to learning about different roles and diversity as a disruptor to flow. I now present findings on redundancy.

Case B: Redundancy

Generally, redundancy in Case B related to how students connected their contributions to other contributions within the case. As illustrated in the diversity section, there were limited areas of overlap or flow in Case B. Limited flow could have been the result of students' lack of understanding of each other's role in health care (i.e., too little redundancy). For example, a student spoke of experiences with interprofessional education:

> *They say interprofessional care, and that's that's pretty well as far as it goes. Like it would be handy to have more of a unit on, you know, what everyone else did,*

> *like in the other professions versus like, "this is your kinesiologist, interprofessional care", and they are move on…you know (B1).*

The student elaborated and identified how knowledge of professional roles may have contributed to effective collaboration:

> *If I had more knowledge of what their roles were in hospitals and stuff I think I would be, even though (.) was a stranger I would be able to work with her much more effectively (B1).*

The student described his experience with classroom learning during his undergraduate degree. The other two students reported similar experiences thus far in the undergraduate education, suggesting these students admittedly have limited understanding of what other professions contribute to patient care. A lack of understanding of professional role, combined with how Case B emerged as segmented by topic area (as illustrated in the previous section), was likely counterproductive to students experiencing redundancy in the case. It was as if the students were interacting with the case as three separate students and never experiencing enough redundancy to form a collective group. However, redundancy did seem to play a role in how students connected their contributions within interprofessional education.

Redundancy as a connector within interprofessional education. Although students identified how diversity supported varying contributions, they also suggested that these diverse perspectives were connected. Redundancy seemed to be more of an individual conceptual piece to this case with students connecting (or not connecting) the topics. An example of such a conversation:

> *You naturally kind of start to meld together. Because everything in this scenario is interconnected like, um, psychological aspect of care is like hugely important for even like physical…plain physical needs and so like that interconnects with the patient, it interconnects the professionals as well (B1).*

Returning to a quotation used in the previous section to demonstrate diversity and redundancy:

> *Everything interconnected so when she is talking about the psychological and then Mr. Sampson said that he was worried about the dressings, his care, then (.) took over and then when he was talking about the nutrition then I took over and then talked about the exercise and then it just kind of went together (B3).*

From these quotations, students do not appear to have experienced much overlap, but, instead, despite the lack of overlap, there was a connection between the knowledge they contributed individually to the scenario. Returning to the perspective of complexity theory in an attempt to understand what had occurred, the diversity was at too great a level and redundancy too low, for students to begin to self-organize and support an emerging conversation where learning could occur.

Notwithstanding, there was one instance in the pre-simulation where redundancy appeared to assist students to learn with, from, and about each other. The example relates to mental health as outlined in the following researcher observation:

> *At approximately 16 minutes into the pre-simulation, students are discussing priorities for the patient. Students continue to suggest priorities to the group with very little discussion or elaboration on those priorities. Students do not engage in a flowing conversation and this is possibly due to high levels of diversity and/or*

> *insufficient levels of redundancy between students. However, one priority that students discuss that results in some elaboration and interaction is psychological health. When one student raises a concern about the patient's psychological health and frustrations, the other students elaborate on this concern. They discuss the patient's financial status, mental status, motivation, and how these three items are connected. This is the first instance in this scenario where students elaborate on each other's points and add their perspectives. At the end of the discussion, the students all agree that the patient's psychological health is an important component to his overall prognosis and ability to succeed once discharged. Likewise, they enter into a discussion related to a fourth profession that is required but absent, social work. Observing this interaction, that lasts approximately four minutes, it seems that students are learning with, from, and about other because they are discussing the patient's priorities, what the patient requires, what professions should be involved, and how different components of the patient's health combine in a holistic manner for overall health (19:00) (RO).*

In the above example, the patient's psychological health provided a foundation where redundancy could begin to support self-organization and emergence. Once students began discussing psychological health, they benefited from their professional diversity (they all had a varying perspective to contribute) and were able to connect contributions in a way that resulted in a discussion. Such opportunities can be thought of as being relatively unpredictable because, despite educators determining learning outcomes and scenarios, it is often unknown how the learners will direct they learning

when they are charged with learning with, from, and about each other. In Case A, it was nutrition that sparked an emerging conversation, whereas in Case B it was mental health.

Summary of Case B redundancy. Redundancy in Case B related to how students where able to make connections between individual contributions. I now discuss the predominant themes in Case C related to diversity and redundancy.

Case C: Diversity

In Case C, diversity related to a foundation for interprofessional learning.

Diversity as a foundation for interprofessional learning. Students in Case C clearly experienced diversity within the simulation as a foundation for interprofessional learning. A student commented on how observing students was beneficial to their learning:

> *There would be certain things like, that I would be thinking but then someone else would say it but they would say it in a different way. I don't know, I find that really nice for working with other people too because then they, you see them do something a certain way and then you're like, "oh, I'm going to do that next time, or maybe I should approach the situation that way and ask those kind of questions" and I thought that was very interesting (C2).*

The same student elaborated on this point later in the focus group:

> *I think there was one situation where, um, you , oh, it was when we were talking about the finances and then I said something but it was the same thing that you said but it was just said in different ways…but it's just like, we all use different words to describe different things right, so like, being able to have different*

> *professions explain different things in different ways might make it easier for them to understand (C2).*

In these two quotations, the student identified diversity as critical for interprofessional learning. Specifically, the student suggested that the ability to observe other students engaging with patients and witness the diversity and similarities (redundancy) within the group during interactions was important. A different student reaffirmed that observing diversity contributed to overall learning:

> *Well just like looking at the nursing students and that they've had experience talking to patients and stuff it's kind of cool to see how warming they are right off the bat like initially they came in and they were the first ones to talk and obviously they have more experience than us and ah, ya, that was kind of a learning moment for me (C4).*

The following quotation from a different student supports the idea that creating opportunities for students to witness diversity within a group contributed to how the group adapted and learned:

> *Seeing how each, ah, each different professional is taught to interact with their clients…As nurses we're taught one way. You know, we are taught certain questions to ask…like, you're healing, your not there to for diagnosis ((several people talking in background)), you're there to heal and treat. ya, I noticed you touched his hand at the end and that's like a nursing thing. But then seeing how a social worker approached the client and what do they say, and what are their, like their ways of interacting and what questions are they asking or, seeing the kin student and they way their taught to interact with the patient and those different*

> *levels and you pick up things from each different profession and, you're like 'oh wait, that is a good way to interact… ya just by hearing them deal with the situation and then picking up on their cues and it's like, wow, that's a different way (C3).*

In this quotation, the student identified how diversity contributed to learning with, from, and about each other. The idea of contributing to others' learning through diversity was echoed by a second student:

> *It's okay to like put your hand on their shoulder, it's okay to kind of like, do certain things, like, seeing someone else do it, I know seeing other nurses do certain things I'm like, "I'm going to do that next time because that was great the way you did that" so I feel like I taught you guys that….that's it's okay (C2).*

The following quotation suggests students will continue to learn (i.e., learning will emerge) after the case ends:

> *I think a lot of us will reflect on this into our own, like professional abilities right, I mean I'm not going to go home and think of the social worker aspect, I'm going to think, oh, well I should have said this, and, like, but now I know two resources for clients to come and, you know, how I can incorporate other professions within their care (C3).*

In all of these quotations, students identified diversity as a foundation to teach and learn within an interprofessional context. This is an interesting finding because to learn with, from, and about each other, students within the group must also be teaching within the group. It seems, based on the above quotation, diversity enabled a student to locate himself or herself as a contributor to another student's learning.

Turning to complexity theory, diversity is required for a system to adapt and learn. The aforementioned quotations illustrate how diversity acted as a foundation for interprofessional learning within the simulation. Students self-organized as they interacted with the environment (i.e., the simulator, the other students, etc.). Diversity supported learners to learn and teach. As a result, they collectively engaged in interprofessional education. Without sufficient levels of diversity (and redundancy), the system would not have been creative enough to sustain such learning and adaptation. Students would have simply observed similar ways of interacting with patients and each other. Instead, diversity was the foundation for interprofessional learning in Case C.

Despite difficulty observing diversity during the simulation, there was an instance in Case C that demonstrated how diversity could act as a foundation for interprofessional learning. The following researcher observation:

> *The four students have just entered the simulator and begin speaking with the patient. They are introducing themselves using their names, profession, and level of program. Immediately the patient asks the students who is in charge. Similar to Case A, the students seem slightly surprised by this question and look around at each other. One of the students responds that nobody is in charge and they are simply working together. (RO).*

Students were faced with some uncertainty immediately upon entering the simulation. Collectively, the students acknowledged diversity was required to collaborate and ensure the patient was ready for discharge. This is similar to how Case A handled this portion of the scenario. Conversely, in Case B, students entered the simulator and did not immediately introduce themselves and the patient had to initiate the discussion. When

the patient commented on the number of people in the room in Case B, the students did not discuss how the team fit together and instead continued to interact with the patient using a segmented and individualistic approach. Returning to all cases and using complexity theory to understand the similarities and differences, it appears Case A and Case C had sufficient levels of diversity (and redundancy) to self-organize with an effective change in behavior. They were able to navigate uncertainty and remain cognizant of the importance of diversity for both interprofessional education and interprofessional collaboration. Contrary, although Case B self-organized, they remained individualized and did not appear to benefit from the same effective/positive behavior to support interprofessional learning.

Shifting now to diversity during the post-simulation, there was limited opportunity to observe instances of professional diversity. Nonetheless, there were some moments during the post-simulation where diversity appeared be a foundation for interprofessional learning. A researcher observation from early in the post-simulation:

> *Within the first two minutes students are discussing things they could have done differently in the simulation. They are all engaged in the discussion and there is energy due the simulation finishing moments earlier. One of the students raises the point that they could have been less formal and less structured during the simulation. Immediately all of the students agree verbally and nod their heads. The students who raised the point then elaborates and provides an example of when she thought they were too structured. Her example is drawn from the simulation when the patient reported he was afraid of dying in the nursing home. The student states that when the patient raised that point she thought it was a*

"perfect social working moment" (1:50). Another student immediately agrees. She then goes on to state that they could have addressed that point with the patient right away but instead "held on for the next profession to talk about" (2:02). The other students agree and this results in further discussion. The word "overlap" is used and students generally agree that there were instances during the simulation where they felt they should address certain issues when the patient raised points yet they did not want to overlap onto someone else's scope (RO).

Students were struggling slightly with the role overlap (redundancy). In the simulation, they experienced diversity yet also experienced redundancy. That is, they became acutely aware of how diverse their knowledge/perspectives are yet how sometimes they are similar. The following researcher observation:

At approximately 5 minutes into the post-simulation discussion, a student raises the point that observing other students was beneficial to her learning. The discussion begins with students discussion how their approach to interacting with the patient was too structured and did not lend itself to a free-flowing and emergent discussion. Instead, students were critical of how structured they were. They reported that the structure was partly a product of being in a simulation with multiple students. However, they acknowledged that the structure, most notably how other professions interact with a patient, was beneficial. One student spoke about how she observed another student interacting with the patient and reflecting on how she would act in a similar situation. She then compared the learning that occurred in the simulation as a result of observing others interact

with the patient with her experience in clinical were observation of other professions is rarely available (RO).

In the above researcher observation, it is clear diversity was an important component to interprofessional education. Turning to complexity theory, the diversity available within the group of students made it possible for a range of different responses by the group. As students observed one another interacting with the patient and reflected on how they may handle similar situations, the possibilities that diversity afforded the group of learners was amplified and became an important foundation for interprofessional learning. Students took what they observed and experimented with it during the simulation, thus resulting in more opportunities for observation and learning. Diversity afforded experimentation when learners were provided an environment where they could explore what they might do as opposed to what they must (or must not) do (B. Davis et al., 2007).

Summary of Case C diversity. Diversity within Case C related to diversity as a foundation for interprofessional learning. This was a similar theme as Case A. I now discuss redundancy.

Case C: Redundancy

Redundancy in Case C related to redundancy as a contributor to flow and redundancy as an equalizer between students. In the interest of space, I discuss redundancy as a contributor to flow. I report on this theme because it was a key theme across several cases, and, within Case C, it had the most data supporting it. Further, and similar to Case A, in combination with the diversity theme, redundancy as a contributor

to flow and diversity as a foundation for interprofessional learning are complementary in the context of complexity theory.

Redundancy as a contributor to flow. Redundancy supported interaction and contributed to the flow of conversations. A student spoke of how, collectively, the group maintained adequate flow:

> *Through body language or like ((Background agreeing)), or someone's like starting to look uncomfortable and ((Background laughing)) and you're like "oh, okay, I don't really know what to say anymore", or like, for example when were talking about signs of infection, like there was some additional things that like, I knew that you didn't know, but, you did a really great job though saying the signs of infection and there was just extra things that I could add to like, cause it's not really about what I know and what she knows, it's about how our patient's going to benefit from what both of us are together so like, being able to like, like collaborate (C2).*

This quotation substantiates redundancy as a support to flowing and interactive discussion. Furthermore, the flowing and interactive discussion contributed to opportunities for students to learn with, from, and about each other. The student's quotation is powerful in that she stated the important part of the interprofessional simulation was not about diversity in knowledge, but rather in how diversity in knowledge combined to benefit the patient. Turning to complexity theory, it appears that sufficient levels of diversity and redundancy occurred in Case C. With diversity and redundancy present, it is plausible to suggest that students self-organized within these conversations and that new behaviours and understandings emerged as a result. One

cannot expect students to identify self-organization or emergence, as students would not be aware of either occurring. However, students experienced free flowing conversations that, when they started to drift in focus, another student would add to the conversation to keep it going. Through such flowing conversation, new ideas and understandings occurred. The following quotation supports this idea:

> *We all use different words to describe different things right, so like, being able to have different professions explain different things in different ways might make it easier for them to understand. That's why I think it's so important that everyone knows everyone's plan, so like, that's why, what I was saying earlier like with rounds, instead of the nurse just saying this is my patient this is what's happening, having like the social worker be like, "hey, this is what we can do" so then everyone's on the same page so you can maybe approach it in a different way (C2).*

Likewise, the following quotation, describing the simulation, suggests how some structure with enough opportunity for free flowing conversation (supported by diversity and redundancy) aided the interprofessional education:

> *I would describe it like fluid structure. So, it was kind of like, you give us this little ditty here of the case scenario, um, so that is like our structure and so our structure was kind of like the pre-simulation part A where you kinda like, kinda structure our thinking but not really … So it was structured in a sense that you have certain things that we should bring up in our conversation with him but it's also fluid because there's so many, you leave so much room for us to like add our own ideas, … so it's structured in that sense but also if you have a group kind of*

like ours where we have all these ideas and you want to do all these things it allows us to go above and beyond…….it didn't' really structure our learning but it did because we were able to like explore our own ideas and practice our own things. So, ah, in that sense you structured it by giving us the situation but you didn't structure it because we were able to kind of do our own thing and explore our own ideas (C2).

According to complexity theory, students experienced the simulation as a proscribed activity as opposed to a prescribed activity. A proscribed activity provides sufficient constraint to orient a learner (e.g., the goal to discharge a patient) but with enough flexibility for studies to arrive at the outcome in different ways (B. Davis et al., 2007). Students were able to self-organize and, as a result, interprofessional learning was able to emerge. The following researcher observation from Case C demonstrates how the students experienced a free-flowing discussion:

Students are approximately 12 minutes into the pre-simulation discussion. They have taken turns sharing their priorities for the patient and are now, without any direction, moving into a stage that is noticeably different from the first part of the session. They have developed a list of priorities but continue to discuss new priorities. However, contrary to how the group interacted during the first part of the pre-simulation, students are now elaborating and discussion priorities as they are suggested. One student suggests that the patient's pain and dressings (i.e., bandages) should be a priority. Another student immediately questions whether he would be able to have someone come into the home and assist with dressings and pain control. The students seek clarification from the facilitator/researcher

> *regarding the type of community the patient resides in. Once they have an understanding of the type of community, a third student immediately raises the point that the type of care in the patient's community may be limited and the group will need to consider resources available. This leads to a discussion about how they can incorporate the patient's family in teaching and dressing care. Every student is involved in the interactive discussion and it is flowing in many directions related to pain and dressings (RO).*

In the above researcher observation, it is apparent the facilitator had very little control over the direction of the conversation once students began to explore the case. Students benefitted from sufficient, perhaps optimal, levels of redundancy related to dressings and pain management. These students came from diverse backgrounds, yet the redundancy in their understanding of the topic facilitated the ability to carry out such a rich and broad discussion. These discussions, as demonstrated in the observation, were non-linear in nature given that the input (the information provided in the case scenario) could not be linked in a proportional fashion to the discussion and learning that occurred as students learned with, from, and about each other. Students acknowledged the unpredictability of the case:

> *I think it's a safe bet to have an idea of what you are going to talk about, but then ya, if it does trail off or spin somewhere else then you have that ability to go that way or in that direction and maneuver with the patient because it is supposed to be about them and not our specific needs (C3).*

> *So being prepared with all the 'trailing offs' that could be potentially happening. It's kinda like a tree with the branches and the leaves right, everything is going to lead somewhere (C2).*

Redundancy contributed to flow in Case C. Self-organization was embodied by the flowing conversation amongst students within the case. As a result, aspects of interprofessional learning occurred.

Summary of Case C redundancy. Redundancy in Case C related to redundancy as a contributor to flow and redundancy as an equalizer between students.

Case D: Diversity

In Case D, students repeatedly emphasized how diversity was experienced through interaction in the simulation and contributed to their learning.

Diversity through interaction. The common theme in Case D related to how diversity was experienced through interaction in the simulation. Students repeatedly spoke about how the diversity between participants was observed and heard throughout the case. The following quotations demonstrate how observation of diversity contributed to learning:

> *I've never had to go and help them with these plans and talk to them in the clinical setting and I notice that you took charge, actually both of you [referring to nursing students] did, like you knocking on the door and like "ah Mr. Sampson" and you kind of like, you set the tone for me and you were able to kind of like teach me some of that but by just observing you guys. And just seeing how…you worded yourself and how you approached things um which is something that we don't get because we don't' learn…even when were talking*

outside of the scenario with the, with your experiences and your clinicals, and talking to patients and having them say something very abrupt and it kind of catches you off guard and how you kind of counter that and how you how you can kind of turn things around from there (D3)

I kind of liked learning the interaction in a hospital pretend setting. Cause like, nurses, like that's used to have that all the time like you're always in here and in the other lab and stuff whereas in psych, we're just in classrooms (D4).

Both students above spoke directly to learning with, from, and about each other in an experiential learning setting. Diversity supported the learning these students described. Turning to complexity theory, it appears students are referring to emergent learning as the learning occurred partly due to the evolving conversations of the other students and the patient. A facilitator responsible for planning the scenario could not have controlled or caused these conversations; they simply occurred based on how certain students were taught or expected to behave with patients (i.e., the local rules). As such, one could describe what occurred as self-organizing conversations that resulted in emergent learning. Sufficient diversity provided the fertile ground for learning with, from, and about each other. Likewise, such learning is difficult to control and pre-plan and, thus, exhibits an element of unpredictability.

Students in Case D viewed opportunities to engage with and observe other professions, such as clinical opportunities or simulation opportunities, as supportive environments to learn with, from, and about each other. Likewise, they acknowledged such opportunities as important if they were to become practitioners who could

competently practice collaboratively. The following quotations, which are very similar to what students reported in other cases, support this idea:

> *The main thing is learning what other professions do. I think a lot of the time people don't, like, we all have a general idea of what other professions do but do we really know exactly what they do, what their scope of practice is…so having the practical experience of being able to sit down and actually work on a team and having those team building skills and team work kind of skills (D3).*
>
> *I think that being from different professions and having the different backgrounds we focus, a lot of the time when we look at something we have like a set mentally that we put on to it and we focus on certain things, and I think that we learned a lot with each other because we were able to kind of like, point out things that maybe others didn't notice right away (D3).*

Students in Case D discussed how diversity might have contributed to opportunities to learn with, from, and about each other. Two of the students in Case D commented on how they observed other students highlighting and writing things down during the pre-simulation. Two students discussed observing each other during the simulation:

> *Looking around and watching people highlight things, I could tell that certain people were highlighting certain things that I wasn't highlighting…, or I was highlighting things they weren't highlighting, so certain things definitely were standing out to different people (D3).*
>
> *I picked out laundry was the first thing that I had written down. Like the first thing that you underlined with the family (D4).*

Students observing what the other students highlighted and wrote relates to the notion of diversity as experienced through interaction and supports interprofessional learning. What is less understood in interprofessional education is the process through which diversity may contribute to interprofessional learning (i.e., learning with, from, and about each other). In the above quotations, something as simple as observing another student engage with a written case scenario could lead to learning, as evidenced in the above dialogue. The students were asked whether they considered their engagement with the case scenario during the pre-simulation as teaching:

> *I didn't think about teaching…(D4)*
>
> *It just kind of happens, like you say something, and they are like, oh, I never thought about it like that or something like that (D5).*
>
> *I think that we were indirectly teaching each other because like we went off…like we talk about something and then we talk about our other experiences and by doing that we were indirectly, even if we weren't thinking about it we were teaching somebody a little something about the stuff we've experienced in the past or like different examples that we have that might help you in seeing were we are coming from and stuff and then that furthers your learning (D3).*

Turning to complexity theory, these students individually engaged with the case scenario using their professional perspectives (i.e., cognitive schema). As a result of this diversity, new learning emerged. Turning specifically to B. Davis et al. (2007), the case was the "enabling constraint" to learning as it offered a specific focus for students (i.e., discharge a patient with a set number of issues). An enabling constraint, or liberating constraint, relates to a proscribed approach to learning and refers to an adequate amount of

constraint to orient a learner yet allow for flexibility and randomness in the experience. (B. Davis & Simmt, 2003; B. Davis et al., 2007). It is a proscribed activity where the rules are not specific as to what one must do (i.e., learn the content to pass a test). Instead, the case is constrained to a focus (discharge a patient with a set number of issues), but one may approach the case and the goal in many ways. Furthermore, with regard to the issues, the issues themselves were layered enough to support diverse ways of addressing them. In the above quotations, students spoke directly to how the case provided an enabling constraint with sufficient levels of diversity to support self-organizing behavior and ultimately new learning (and teaching) to emerge. Diversity, as experienced through interaction, contributed to interprofessional learning.

Diversity supported interprofessional learning through interaction during the simulation. At certain points in the scenario, students were cognizant of how a gap in their understanding created an opportunity to learn with, from, and about another student. Likewise, some students recognized that a uni-professional perspective was insufficient for providing optimal care in this scenario. The following researcher observation presents an example of how one student recognized a gap and sought to fill that gap from another student's knowledge.

> *At approximately 12 minutes into the scenario, students are discussing priorities. Up to this point the conversation has been very interactive and free flowing. Students have required minimal facilitation and there are minimal questions or silence. One student raises a question about the type of community the patient resides in. After answering the question, the student draws upon two other students in the group and asks them directly about how, from their professional*

perspective, they feel about the placement of the patient's laundry facilities in the basement (the patient fell while transporting laundry to the basement). She states specifically "now, you guys are psychologists, what do you guys think about a 71 year old man and his wife….the basement situation…what do you think they'd be feeling about going back to the basement?" (12:16). Both psychology students immediately respond and agree that the patient would likely attempt to navigate the stairs again. This question leads to a discussion lasting several minutes about a home assessment and a mental health assessment, and how the findings of those assessments will lead to other areas to explore with the patient. The discussion draws upon how multiple areas of the patient's health are related (i.e, mental health relates to nutrition which relates to activity which relates to mental health). This discussion involves all five students and covers wide array of topics (16:45) (RO).

In the above researcher observation, the catalyst for discussion was a student purposely drawing upon the professional perspective of another student. Turning to complexity theory, one could say that throughout the discussion, which was created by sufficient levels of diversity and redundancy, the conversation self-organized and was directed by points students raised based on their professional backgrounds and understanding of the topics. As the conversation self-organized and students listened to contributions from other students (i.e., learn with, from, and about each other), the learning emerged in and from the collective. During the pre-simulation, as a facilitator, I had limited active involvement in directing the conversation aside from creating the case scenario and guiding questions. To use B. Davis et al. (2008), I needed to have "faith in

the intelligence of the collective" (p. 197) and conceptualize the case scenario as an enabling constraint. As illustrated in the above researcher observation from Case D, it appears that sufficient levels of diversity (and redundancy) provided an optimal environment for the intelligence of the collective to engage with the enabling constraint and thus create an opportunity for learners to learn with, from, and about each other.

Summary of Case D diversity. Diversity in Case D was related to how students experienced diversity through interaction as a foundation for interprofessional learning.

Case D: Redundancy

In Case D, redundancy contributed to students experiencing flow in their conversations and redundancy as overlap. In the interest of space, I discuss redundancy as a contributor to flow. Similar to previous cases, I focus on this theme because it was common across other cases, was supported by more data, and is complementary to the diversity theme in the context of complexity theory.

Redundancy as a contributor to flow. In Case D, students referred to the experience of "flow" or "fluid" as "playing off each other." In the following quotations, students discussed how they navigated any uncertainty in the case. Within this discussion, it is apparent that redundancy (and in a complementary manner, diversity) supported learning with, from, and about each other as students "played off each other":

I think we did generally pretty well. I feel like we played off each other (D1).

That is what I was going to say (D2).

What do you mean by played off each other? (researcher)

As a nursing student if we mentioned, like, going back to the fall, like, oh, you had another fall, why did you fall, and then coming from a pysch perspective, like,

again, was that mental health wise, is that why he fell. Something like, you picked up little things that the other person would say and you could like play off, like if someone's speaking and you're like, oh, I want to add to that idea, and then you wait, and then you mention it again, so if I said something like, like with the life alert, like, like, pysch you could be thinking something completely different. Like you play and learn off each other…we didn't know everything about this case but then you brainstorm and you pick up little things that maybe you could assume (D1).

During the simulation I feel like we just kind of tested each other you know, you let the person have the floor and then, we talked after if we had something to add. Or like, um, when {} suggested the chairs, we just started grabbing chairs because we trusted her and sitting down was the best option for us so I think we just trusted each other (D5).

I think trust is a big one because I think that there's like this urge to micro manage your patient and make sure that, "no no no, I got this", and it's just like, um, ah, I think that fact that we were able to kind of like listen to each other. Even though there was something…there was something where, I forgot what it was but there was a time when someone was saying something and I was like, "oh, I know all about this" but I just stayed quiet and I let them finish instead of like butting in and saying "okay, this is how we are going to do this' because, and I think having like that faith in your colleagues and knowing, being like okay, they can handle this, and knowing when to kind of intervene and knowing when not to (D3).

When we're at the table here, um, we could, with uncertainties we ask each other, we learn from each other and go back and fourth whereas as like at the bedside, kind of turn that down a bit and wait, like what you guys said, wait for the person to be done and then if it's necessary and then add your point later (D4).

I don't think one person took control, I think that like someone would mention something that they thought was important and then you know other members of the group would add what they, you know, their views on that was or whatever and it was just kind of like a group discussion (D2).

In the above discussion between all five students, it is clear students experienced the simulation as flowing, fluid, or playing off each other in a manner consistent with students in the other cases. Turning to complexity theory, as I have done in previous cases to explore the experience described by students, sufficient levels of diversity and redundancy were present to support interprofessional learning. Specifically, students learned through discussions with each other and observing each other. There was sufficient redundancy to allow students to make sense of the discussions and observations from their individual perspective. Likewise, there was enough diversity to allow students to "add to" what others were saying. The case acted as the enabling constraint as students had the opportunity to explore many options to achieve the goal. As a result, collective learning emerged and students were able to learn with, from, and about each other. This fluidity, flowing, or playing off each other was described by students across all cases.

In the above quotations, students also referred to trust. Trust is an important concept in interprofessional education (and collaboration) because learners may not understand the perspectives offered by learners from other professions—they may not

comprehend others' cognitive maps (McMurtry, 2010). As such, trust becomes an important enabler. In terms of complexity, McMurtry (2010) identified trust as being a form of commonality that helps overcome diversity—said another way, trust could be considered a form of redundancy, or similarity, that complements the diversity and contributes to collective learning.

Students entered quickly into a flowing interactive discussion within the simulation. The following researcher observation demonstrates how redundancy was a contributor to the type of flow witnessed in Case D:

> *It is approximately 7 minutes into the pre-simulation. Students have finished reading the case scenario and have begun to collectively create a list of priorities to address with the patient. The first student to speak, a male from a senior year, raises his priorities with the group. They include family dynamics, weakness, weight loss. They student eloquently links these three areas together and discusses how they overlap in terms of the patient's overall prognosis to continue living at home. He uses the profession-specific term of 'cognitive dissonance' to describe how the patient may experience his joy of activities given his current physical situation. The point about cognitive dissonance and possible loss of activities prompts a junior student to suggest kinesiology, a profession absent from the group, would be a helpful addition to the patient's situation. The group seems to agree with the point and a third students suggests that he could be successful in the social aspects of activities if he is simply around the activities and not necessarily taking part immediately. She uses the example of curling (which is common across all cases) but states that simply going to the curling rink and*

perhaps not necessarily participating in the curling could be a healthy alternative. A fourth student immediately adds to this point and draws the groups attention to how a fractured hip will heal and that the patient, with the proper treatment and rehabilitation, will can resume a pre-injury lifestyle. The group then enters into a discussion about whether weight-loss and strength is a result of or a cause of his fall.

In the above researcher observation, students were able to enter into a flowing and interactive discussion due to sufficient levels of redundancy. As illustrated, students were able to move collectively from one topic to the next and ultimately fill in gaps as they progressed. Such redundancy could have been a result of only having two professions present, and, therefore, a high level of sameness across students supported an interactive discussion. Nonetheless, it is apparent that the sameness enabled students to cover a broad range of topics in their discussion. Turning back to the focus group data, the sameness that students experienced could also be explained by the comfort they felt from all being students. The following quotation supports the idea that being a student created redundancy and, therefore, supported flowing discussion:

I don't think there was any sort of hierarchy here which may be different in the real fields in terms of, you know, there's doctors, then there's nurses, and then there's RPNs, or there's psychologists and then pysch associates it might not….maybe because we are all students so we are all really on the same level but it might be different in the real world (D4).

From the above quotations, it is clear that the redundancy created by being a student was an important part of creating an environment for learning with, from, and about each other.

Although redundancy was not as apparent during observation of the simulation, it was apparent, albeit to a lesser extent, during observation of the post-simulation. The following researcher observation highlights how a sufficient level of redundancy was experienced in the simulation lab and then consequently supported a conversation during the post-simulation that likely lead to interprofessional learning:

> *At approximately 10 minutes into the post-simulation, students are discussing any shifts they feel would make in their performance in the simulation. One student raises the point that based on what the patient said during the simulation, she felt that mental health would likely become more of a priority than she originally thought. As soon as she raises this point, the other students nod and agree. She then relates mental health to appetite and eating and suggests that many of the patient's health issues relate back to mental health. As the other students agree, she raises the example of how the patient responded to a particular question during the scenario. A second student immediately agrees and draws on her experience to substantiate the first student's point. The other students are nodding during the discussion. The student who raised the original point appears to control the discussion, but the other four students all seem to agree with what she is saying and a second student frequently substantiates the first student's points (RO).*

In the above example, students were collectively reflecting on what they might do differently in the scenario if given the opportunity to repeat their experience. The mental health aspect appeared to create some redundancy and enabled students to reflect on and better understand how the patient's health conditions were related. Both mental health and the experience in the simulation created sufficient diversity to support such a discussion.

Summary of Case D redundancy. In Case D, redundancy was a contributor to students experiencing flow and redundancy as overlap.

Summary of Results from all Cases

All cases were provided the same patient scenario; yet, there were similarities and differences for how each case proceeded. Using diversity and redundancy as coding concepts, I was able to organize data using complexity theory. Once organized using complexity theory, I was able to identify key themes within each case (Table 5.2). Although there were less prominent themes within each case, due to space restrictions, I only presented the most prominent and complementary themes (Table 5.3). In Chapter 6 (Discussion and Conclusion chapter), I offer a discussion and implications for educators charged with designing and implementing interprofessional education. Further, I present limitations of my research and implications for future research.

CHAPTER SIX: DISCUSSION AND CONCLUSION

My research was aimed at exploring interprofessional education from a complexity theory perspective. Two studies comprised my research. First, to help inform a case study of interprofessional education, I undertook a scoping review of how complexity theory has been used in health services research. The findings from the scoping review were combined with findings from my literature review to help inform my case study. Second, I conducted a multiple holistic case study to explore interprofessional education from a complexity theory perspective.

Conducting the scoping review served a purpose as the results combined with the findings of my literature review to help inform the theoretical foundation for my case study. My initial literature review uncovered variability related to how researchers have used complexity theory to study phenomena in health. Specifically, researchers have defined and used complexity theory in many different ways and it was unclear what approaches would be most fitting for my research. I found the variability troublesome given that debate exists related to the proper use of complexity theory in health research (Greenhalgh et al., 2010; Paley, 2007, 2010). More specifically, as a novice researcher attempting to use complexity theory to inform a case study, it was unclear from the literature how complexity theory should be used, what components of complexity theory are most useful, and if complexity theory was appropriate to study issues related to health—specifically interprofessional education. As theoretical foundations are critically important for case studies (Anderson et al., 2005; Crabtree & Miller, 1999; Yin, 2013), the lack of direction in the literature was problematic. Therefore, I sought to develop a

greater understanding of how complexity has been used to study phenomena related to health and use the findings to help inform the case study portion of my research.

Briefly, 44 studies met the inclusion criteria of the scoping review. Of these 44 studies, 27 were qualitative, 14 were quantitative, and 3 were mixed methods. Qualitative case studies involving nursing and medicine in long-term care and primary care were the most common form of research employing complexity theory. Other settings were studied, and quantitative and mixed methods were also used. Exploratory or descriptive research examining interactions/relationships and management were the most common. Eighteen different concepts of complexity theory were found in the literature. The most common concepts were relationships, self-organization, and diversity. Although descriptions varied, there was similarity across some studies with authors often referring to how complexity theory could help examine how change is influenced by diverse relationships and communication within a system.

For the second study in my dissertation, I conducted a multiple holistic case study approach guided by Yin (2013) using interprofessional education sessions within a simulation environment. Four interprofessional education sessions, which I developed and implemented, formed my cases. Using direct participant observation (i.e., researcher observation) and focus groups, I collected data to provide examples of how interprofessional education appeared from a complexity theory perspective. Specifically, I used diversity and redundancy as a priori codes to initially categorize my data. Once organized, I identified key themes within the categories. I used analysis frameworks by Creswell (2007) and Crabtree and Miller (1999). Specifically, Crabtree and Miller guided the initial categorization as they provide an approach to working with an a priori

codebook. Then, I used Creswell's data analysis spiral to assist me in identifying themes within the data according to complexity theory.

Diversity and redundancy formed the codes. For diversity, I was guided by B. Davis and Simmt (2003), B. Davis and Sumara (2006), McMurtry (2010), and Page (2008). I defined diversity as the different ways that learners contribute to learning with, from and about each other and ultimately to the group's intelligence (McMurtry, 2010). I used diversity to identify, within the focus group and researcher observation data, instances where differences across learners appeared to influence interprofessional education within the case. For redundancy, I was also guided by B. Davis and Simmt (2003), B. Davis and Sumara, (2006), and McMurtry (2010). I defined redundancy as sameness that supports interaction and gap-filling within a group. I used redundancy to identify, within the focus group and researcher observation data, instances where sameness between participants appeared to influence interprofessional education. Once data was categorized according to diversity and redundancy, I then identified key themes within the categories. The key themes related to diversity I identified in the data were diversity as a learner expectation, diversity as a foundation for interprofessional learning, diversity as a multifaceted component of interprofessional education, diversity as a way to learn roles, diversity as a disrupter to flow, and diversity through interaction. The key themes I identified related to redundancy were redundancy as a contributor to flow, redundancy as overlap, redundancy as a connector within interprofessional education, and redundancy as an equalizer between students. Due to space constraints, I reported findings for one theme per case.

The keys questions that guided my research were (i) *how has complexity theory been incorporated in health services research* and (ii) *how does interprofessional education occur when viewed from a complexity theory perspective?* The overall purpose was to study interprofessional education for health students using attributes of complexity theory (specifically diversity and redundancy). In doing so, I aimed to use complexity theory language to describe aspects of interprofessional education. Thus, the themes I identified within the cases are examples of how one could describe what occurs within interprofessional education using complexity theory language.

In this chapter I will discuss some of the findings from both studies that comprise my doctoral research. To start, I will extend the discussion offered in chapter four (scoping review). Specifically, I will discuss how my findings compared to existing literature, offer some explanation for the variability of how complexity theory has been described and used in health services research, and consider why qualitative case studies examining relationships was most common. Next, I will situate key themes from my case study in existing research and offer some explanation for my findings—notably the themes related to "flow." Following the discussion, I will provide recommendations for educators working in interprofessional education and implications for future research. The chapter will close with an overview of limitations and concluding remarks.

Complexity Theory within Health Services Research

My scoping review was the first review to examine how researchers have used complexity theory in health services research. Reviews exploring complexity theory and how the theory aligns with specific health phenomena exist. For example, Sturmberg et al. (2014) conducted a historical review of complexity theory and general medicine. In

their review, Sturmberg et al. determined, in the field of general medicine, complexity theory was first used as a conceptual or philosophical lens through which to describe phenomena. My scoping review suggests similar findings. However, Sturmberg et al. reported that the theory's usefulness has recently shifted from a conceptual tool to more of a practical tool: "A transition from the largely theoretical engagement with complexity science to its pragmatic application" (Sturmberg et al., 2014, p. 72). My results suggest researchers in health services are not shifting away from a theoretical application toward a practical application of complexity theory. Instead, my research suggests authors in health services research are using the malleable concepts offered by complexity theory in various metaphorical ways to describe concepts and phenomena in their work—an approach that is far from a practical application. Sturmberg et al. concluded that complexity theory offers a powerful research framework from which researchers make sense of phenomena—something I also concluded. An implicit finding from Sturmberg et al.'s review was the heterogeneity of how complexity theory was used by researchers in general practice. These authors reported multiple concepts and aspects of complexity theory (e.g., non-linear dynamics, attractors, relationships, self-organization) being used in numerous ways (e.g., case studies, survey designs, observational studies). Heterogeneity was also a key theme from my review findings. Unfortunately, Sturmberg et al. stopped short of commenting on the variability of what concepts are used and how and instead suggested we should begin to move to "pragmatic application of nonlinear dynamics and modeling" (p. 73).

Although Sturmberg et al. (2014) advocated for quantitative application of complexity theory, Wallis (2008, 2009) formed a slightly different conclusion from his

reviews on complexity theory in organizational science. Wallis (2009) determined that complexity theory contained 47 differentiable concepts. From his analysis, he concluded: "Where previously a reader might have believed that authors conversing around the topic of CT [complexity theory] are describing the same thing, the present paper has suggested that is not the case" (Wallis, 2009, p. 35). The results of my scoping review also suggest there are important differences in how authors are defining and describing complexity theory. It was impossible to determine if authors in my review were discussing the same thing when they stated they used complexity theory, or concepts of complexity theory, in their research. Although some authors offered definitions of terms, others did not. Likewise, there was variability in how authors defined and described complexity theory and concepts of complexity theory. Wallis (2009) suggested variability in descriptions creates decreased robustness of the theory. Further, he suggested that robustness of a theory is akin to efficacy of a theory. I stop short of suggesting that more consistent descriptions and definitions of complexity theory and its concepts could lead to a more effective theory. Definitions and descriptions of complexity can be tailored to reflect the phenomena being studied (B. Davis et al., 2007)—and this malleability is what makes complexity a powerful lens through which to view various complex systems. More consistent terminology, descriptions, and definitions would support more effective theory in some instances, but may hinder other applications. However, I echo Wallis' (2008, 2009) sentiment for more effort to determine the key concepts from complexity that might be useful in certain areas (e.g., organizational science, health services research, interprofessional education). In the following section, I extend my scoping review findings, and the findings from existing reviews, and offer some discussion of possible

explanations for variability in how complexity theory has been used and described in the literature. The overarching theme within this argument is that variability is expected as researchers grapple with how complexity theory may look and exist within the broader health literature and the narrower interprofessional education literature.

Variability in complexity theory literature. The variability identified by Sturmberg et al. (2014), Wallis (2008, 2009), and my results is expected. There are two explanations for such variability and it is probable that both explanations are contributing to heterogeneity in how health researchers have used and described complexity theory. The two explanations can be broadly classified as issues related to borrowed theory and issues related to the phenomena of study.

First, complexity theory is not necessarily a new theory, but its application within certain areas, such as health services research, interprofessional education research, and general practice research, is relatively new. Health researchers have adopted complexity theory from other areas and have borrowed the theory. Theory borrowing is popular in organizational science literature and refers to the act of bringing theoretical ideas from one domain to assist with studying phenomena in another domain (Floyd, 2009). The exact history of complexity theory is debatable with authors tracing roots to many different areas. Most would agree that complexity theory arose in the natural sciences and has since influenced thinking in the social sciences—"the social sciences also have seen similar discourses emerge, sometimes under the direct influence of or adaptation from the natural sciences" (Stanley, 2005, p. 12). Application of a theory in a new domain, whether through influence or adaptation, will result in modified and variable

interpretations as researchers grapple with and mold the concepts and propositions from the theory to the new domain (B. Davis & Sumara, 2009).

Paley and Eva (2011) have traced the introduction of complexity theory to health care research (and literature) to a series of articles appearing in the BMJ[9] in 2001. Sturmberg et al.'s (2014) historical review and my scoping review results support the notion that authors have used complexity theory more after 2001, making it plausible the increase is due to a series of publications in BMJ in 2001—in fact, Greenhalgh et al. (2010) noted that the articles in BMJ have been cited by over 900 articles; a number that has surely grown since 2010. Consequently, it is reasonable to assume that the language and descriptions offered by the authors of the BMJ articles were highly influential to future research—yet available for interpretation. Paley (2010) has criticized the adoption of complexity theory within health research as being too reliant upon "received interpretation" (p. 270) of a theory that lacks a definition and has origins away from the social structures in which it is being applied to. Such criticism adds to important debate, but it is not surprising that borrowed theory, a theory that is known for defying definition or a "loose grouping of ideas" (Paley & Eva, 2011, p. 170), could be interpreted by the borrowers in many ways. Therefore, the variability highlighted by Wallis (2008, 2009), Sturmberg et al. (2014), and my research is expected as these reviews were conducted outside complexity theory's original domain. My finding that authors have used 18 different concepts of complexity theory and applied those concepts in a myriad of ways is a product of borrowing theory from the origins of natural sciences and adopting it to explore and solve issues in the social sciences. Variability is expected, and even

[9] BMJ is the official name of the periodical and not an acronym. Originally it was the referred to as the British Medical Journal.

welcomed, but as we move forward, we must strive towards consistency and understanding in how we can use complexity theory in a health and social sciences arena.

The second explanation for variability in my scoping review (and other reviews') findings relates to how the phenomena under study is the determining factor for assessing if complexity theory is an appropriate perspective for informing a study. As I outlined in my literature review, there are simple, complicated, and complex systems.. Simple and complicated systems are systems that can be understood by reducing the system into its parts, studying those parts, and formulating an understanding of the overall system from those parts. Examples include airplanes, automobiles, and clocks. Conversely, complex systems are those systems that are not fully understood using reductionist approaches that work so well for understanding complicated systems (B. Davis et al., 2007). The properties of complex systems come from more than the properties of their components—among other things, complex systems can be unpredictable and changes within the system may not be traceable to specific events (B. Davis and Sumara, 2011). Complexity theory offers perspectives, or metaphors, to assist in exploring and understanding complex systems. Studying a complicated system using complexity theory would be inappropriate, as would be studying a complex system using theory founded on reductionism. It is important to note I am not claiming complexity theory to be "better" than another theory. Instead, I am attempting to illustrate that complexity theory is complementary to other approaches and that when a system is a complex system, complexity theory offers a fitting perspective. The distinction between complex and complicated stems from the properties of the system, or phenomena under study, and

those properties are what creates conditions that make complexity theory a useful perspective.

Paley and Eva (2011) suggested that authors who use complexity theory may not always illustrate the phenomena they are studying are complex systems. Within my scoping review, Paley and Eva's point was evident—authors did not always convince the reader that their focus was a complex system (e.g., Buttigieg et al., 2013; Cucolo & Perroca, 2015), thus raising concerns for the appropriateness of using complexity theory. In many studies, it was up to the reader to determine if a system was complex and how the researchers were using complexity theory.

Arguing that a system is complex before employing complexity theory is challenging. A lack of a clear definition of complexity theory contributes greatly to the variability in how complexity is used. There are some ideas of what constitutes a complex system, but no clear idea that clarifies exactly what a complex system looks like in a social sciences (e.g., health services, interprofessional education) context. A typical definition of a complex system[10] is:

> Complex adaptive systems are defined as collections of many different components (agents) interacting in nonlinear ways in the absence of any external supervisory influence. The behaviors of a complex adaptive system cannot be explained by the behavior of specific agents (reductionism), instead, complex adaptive systems show emergent behaviors. (Sturmberg et al., 2014, p. 66)

[10] In the quotation the term "complex adaptive system" is used. I use the term "complex system". In my argument, and often in the literature, the terms are synonymous.

Within this definition, which is uncharacteristically concise in the context of complexity, are a few key areas that a researcher must interpret to determine if the system they are studying is indeed complex and how complexity theory could be used. For example, the term “agents” could be interpreted as people, “collections” could be interpreted as nursing units, “supervisory influence” could be interpreted as managers of people, and “emergent behavior” could be interpreted as changes within the system. Using these interpretations, one could argue that nurses (agents) working on a nursing unit (collections) make some decisions, such as how to prioritize nursing care, independently (absence of external supervision), and those decisions can change what is valued on a nursing unit (emergence). To add to the last point, if some nurses prioritize their coffee breaks ahead of documenting their care, the culture of the nursing unit changes to be one that values adherence to set break-times (something that is common within the profession of nursing) over documentation (a potentially dangerous scenario). As such, nursing care on a particular unit could be conceptualized as a complex system. However, not all of the decisions nurses make are in the absence of external supervisory influence, and perhaps the nurses who prioritize break-times are influential (e.g., relatively experienced, well liked) and thus have more influence on the culture of the unit while other nurses may not make the same decisions. Do these outlier qualities negate the system as being complex? Must all of the qualities of a complex system be present in a system for the system to be complex? What if there are combined complicated and complex qualities present in a system? What are the boundaries of the system? The answers to these questions are not simple and it is up to individual researchers to consider

them carefully when employing complexity theory. However, even with careful consideration, these decisions are not small and thus variability is the result.

Therefore, given the onus is on researchers to determine, and argue, if the phenomena under study is indeed a complex system (because the phenomena under study is what determines if complexity theory is appropriate), and complexity theory is a "loose grouping of ideas" (Paley & Eva, 2011, p. 170), it is no surprise that Wallis (2009) found 47 components of complexity theory in the literature and I found 18 different concepts of complexity theory being used by health services researchers. With such variability in phenomena considered complex systems and such a large toolkit of loose ideas, differences in how those ideas are used and defined is expected.

In the preceding pages, I have argued that variability in how health services researchers (and inherently researches examining interprofessional education) have used complexity theory in their research is due to issues related to borrowing theory and issues related to the study phenomena. Although such variability creates difficult conditions for reviewing the literature, variability is an expectation as researchers grapple with important decisions around how best to integrate complexity theory within their areas. In the next section, I will offer some explanation as to why complexity theory was most used in case studies examining relationships and interactions.

Complexity theory: Methods and focus. My scoping review is the first study to document research methods used by health researchers who employ complexity theory in their work. Additionally, my findings are also the first to illustrate what phenomena those health researchers are studying using complexity theory and by what methods. Qualitative research represented 61% of the studies located by my review. Likewise, of

the qualitative studies, 63% were qualitative case studies. Clearly, complexity theory appears useful for investigators using qualitative case studies.

Anderson et al. (2005) suggested complexity theory fits well with case study designs. There are two explanations for this fit. First, case study designs rely heavily on theory throughout the entire research process. Unlike other qualitative methods (e.g., grounded theory, ethnography), theory is integrated at the outset of a case study and is used throughout. Yin (2013) stated that case study design essentially embodies the theory being used. Complexity theory is broad and encompasses a myriad of concepts. For this reason, it seems logical that case study designs were one of the most commonly used designs for research that incorporated complexity theory because the concepts and broadness of complexity theory make it relatively malleable as a foundation throughout the stages of a case study. However, there is a second, and perhaps more important, explanation for why case studies were most common in my scoping review.

As Anderson et al. (2005) stated, case studies are useful approaches for studying health care organizations and systems. Furthermore, Anderson et al. suggested case studies are as robust as the theoretical foundation they are based on. This point is aligned with Yin's (2013) notion that case studies depend upon a strong theoretical lens. Anderson et al. extended the idea that case studies require a strong theoretical lens by suggesting researchers were relying on "theoretical models that are not congruent with the nature of the health care organizations we study" (p. 670). Anderson et al. argued that the theoretical perspective that is embodied by the case study approach must reflect the realities of what is being studied. In a sense, this is an argument that the ontological nature of what is being studied must be considered within the epistemological perspective

used by the researcher. A case study approach is a holistic approach to studying natural phenomena—holistic because the contexts of the phenomena are as important as the phenomena themselves (Yin, 2013). Within a case study, the goal is not to reduce phenomena and contexts into separate parts for understanding. Case study methodology is aligned with a complexity theory perspective given that both the methodology and the theory are non-reductionist—they are ontologically and epistemologically matched.

Against some criticism (e.g., Paley and Eva, 2011), many authors have argued that health care organizations are complex systems and are, therefore, more suited for study using complexity theory ideas as opposed to theories based on upon reductionist and/or linear ideas (Anderson et al., 2005; Colon-Emeric et al., 2006; Eika et al., 2015; Forbes et al., 2007). Therefore, based on the notion that case studies require a strong theoretical lens that accurately reflects what is being studied and that health care organizations can be conceptualized as complex systems, it makes sense that qualitative case studies are the most common research method being used by health services researchers who use complexity theory in their research.

In summary, the results from my scoping review, when paired with existing literature, suggest complexity theory is an appropriate theoretical perspective to use when studying a phenomenon that can be conceptualized as a complex system. It is up to the researcher employing complexity theory to demonstrate how the phenomenon under study is a complex system. Furthermore, because complexity theory offers a broad way of thinking about certain phenomena, as opposed to a defined perspective, researchers are able to select from complexity's offerings and tailor concepts to suit the phenomena of study. The messiness in conceptualizing multiple phenomena as complex systems results

in more messiness when one is tasked with choosing the concepts of complexity that may be useful—and together, because of our current understanding of complexity, variability in how complexity is used is the result. Nonetheless, qualitative case study research appears to permit the necessary flexibility in accommodating variability. In the early 1960s, Kuhn (1962) suggested that researchers were only asking answerable questions while overlooking questions that lacked answers. As researchers stretch and amend complexity theory into new areas, as evidenced by the variability in my review and unclear direction in the literature, my hope is that Kuhn was correct when he stated "as in manufacture so in science—retooling is an extravagance to be reserved for the occasion that demands it" (p. 76). I hope I have captured a glimpse of the retooling stage in my review and more research will bring more consistency. In the next section, I will discuss some of the findings from my case study.

Interprofessional Education Viewed from a Complexity Theory Perspective

In my case study, I attempted to explore interprofessional education from a complexity theory perspective. Using four existing frameworks (See Table 3.2) (Canadian Interprofessional Health Collaborative, 2010; Charles et al., 2010; Groom et al., 2014; University of Alberta, n.d.), I designed an interprofessional education session and delivered it using high-fidelity simulation. I repeated the session four times with different participants from different professions. These four sessions formed the cases of a multiple holistic case study design (Yin, 2013). I collected data using focus groups with the participants and researcher observations from the video-recorded sessions. I categorized data using an a priori codebook (Crabtree & Miller, 1999; Creswell, 2007) informed by two concepts of complexity theory (diversity and redundancy) that I had

identified from a literature review (Chapter 2) and scoping review (Thompson et al., 2016) (Chapter 4). The categorization process provided a framework of data from the interprofessional education sessions that represented the two concepts of complexity. Then, I analyzed the categorized data for themes within each category using a process outlined by Creswell (2007). I performed data analysis within each case.

Situating my findings in existing research. Although complexity theory is increasingly used to study phenomena related to both education and health, very little research has been conducted using complexity theory to study interprofessional education in health. Nonetheless, it is useful to consider my findings in light of some existing research on interprofessional education and complexity theory.

Weaver et al. (2011) used complexity theory in a case study design to explore experiences of committee members involved with planning an interprofessional education session in a health setting. Notably, Weaver et al. used a similar process as I did—they performed a deductive content analysis on focus group data collected as part of a case study. Their a priori codes consisted of concepts of complexity theory (e.g., emergence, decentralized control, internal diversity, internal redundancy). Related to the concepts used in my research, Weaver et al. also found diversity among committee members was an important component of planning a successful interprofessional education event. Weaver et al. noted the participants were aware of the need for diversity and that diversity was sometimes lacking. These findings are similar to what I found in several of the cases (as implied by the theme of Diversity as a Foundation for Learning). For example, returning to a quotation from Case A:

We will just like throw ideas out there and talk about stuff and you just like see how the different, like professions connect together and how they fit together and like what her place is and what her place would be in a specific situation (A3).

The participant is clearly identifying the need for diversity in the interprofessional education session. Now, compare the quotation from a participant in Weaver et al.'s work (specifically related to diversity): "It would have helped to have more representatives from the humanities. Where were the folks from literature? I think they would have more to offer. We talk about these things, but we had no profound grasp of the subject" (p. 111). Although contrasting, Weaver et al.'s and my findings are both suggesting participants are clearly aware of the need for diversity and the role of diversity as contributing to the overall intelligence of a system.

It is not surprising that diversity, in essence a difference, was identified as an important component of interprofessional education. After all, the most commonly cited definition of interprofessional education stresses the importance of bringing together students from at least two different professions (Centre for the Advancement of Interprofessional Education, 2002), thus suggesting opportunities afforded by learning with, from, and about each other are supported by mere differences in perspectives. However, as I stated in Chapter 2 (Literature Review), little is known of why these differences matter and what occurs with these differences that make them matter.

Statements from the previous quotations, such as "professions connect together and how they fit" and "more representatives…more to offer", strongly support the idea that diversity is a foundation for interprofessional learning. The idea put forth by complexity theorists that diversity contributes to both the intelligence of a complex

system and the learning of a complex system speaks to the need for ensuring sufficient diversity when conducting interprofessional education. Perhaps the notion that the intelligence of a complex system depends upon diversity is equally as important as the notion that learning occurs with, from, and about each other. As one learns with, from, and about, the other individuals within the system do too; thus, the system collectively becomes more intelligent and changes (emerges) due to the self-organization of its members. When viewed in this manner, building interprofessional education sessions that can accommodate such change becomes more important than ensuring there are different professions present.

Weaver et al. (2011) also reported findings of redundancy in their research. They reported redundancy enabling "reward" and "momentum." My findings are similar in relation to redundancy, as a predominant theme within three cases was "redundancy as a contributor to flow." Admittedly, the terms "flow," "reward," and "momentum," are not synonymous, but there is an interesting overlap. As I will elaborate in the next section, to orient my findings related to flow, the experience of flow occurs when people engage in activities that, among other things, offer a perfect balance of challenge for their skill (Csikszentmihalyi, 1988b). When flow is encountered, the experience of flow becomes the intrinsic reward for the activity. Consider a quotation from Weaver et al.'s work: "I found the collaboration, and the momentum that it fostered to be rewarding…tremendous momentum was gathered" (p. 111). The quotation suggests that during collaboration, the group has momentum toward accomplishing a task and individual reward is experienced. The quotation is very similar to what participants in my study reported experiencing related to momentum: A quotation from Case C:

> *I think it's a safe bet to have an idea of what you are going to talk about, but then ya, if it does trail off or spin somewhere else then you have that ability to go that way or in that direction and maneuver with the patient (C3).*

A similar quotation from Case D:

> *I don't think one person took control, I think that like someone would mention something that they thought was important and then you know other members of the group would add what they, you know, their views on that was or whatever and it was just kind of like a group discussion (D2).*

In both quotations, students are referring to how the collaborative interprofessional nature of the activity allowed them to move forward in their discussion (i.e., momentum) regardless of whether the discussion was building on previous points or "trailing off" (i.e., stalling) or moving in different directions. In these instances, as was the case in Weaver et al.'s work, redundancy is supporting the flow of conversation which, presumably, further supports learning.

My results lend support to findings from another study exploring interprofessional education from a complexity theory perspective conducted by McMurtry (2010). Specifically, McMurtry reported evidence of how interprofessional teams could synergistically come together to achieve collective learning (as opposed to individuals learning within the team). His findings build upon the idea that "team members recursively elaborate on one another's ideas and thereby create collective knowledge that "exceeds the sum of its parts" " (p. 225). He reported that "building upon" occurs through team members listening to other team members and then adapting contributions based on what other members say. Overwhelmingly, within my cases, participants reported

adaptive contributions—which I considered supportive of redundancy as a contributor to flow. Consider the following quotation from Case A:

> *If I said one thing I'm sure it sparked an idea in someone else's head and that's where it kind of went from and it just kept going it seemed and even if we started with a question, we would sometimes end up in left field but it's because you say one thing which sparks another thing which sparked another thing…so I think it just kind of unfolded that way (A3).*

The above quotation illustrates how, with slight redundancies in knowledge (and complemented by diversity), the conversation (and presumably the learning) occurred. Using McMurtry's findings, such instances of redundancy account for the notion that, from a complexity perspective, this flowing conversation that seemingly builds off previous conversations is how the collective knowledge becomes more than what can be known individually.

Flow as a component of interprofessional education. After categorizing data based on diversity and redundancy, two themes related to flow emerged: redundancy as a contributor to flow and diversity as a disrupter to flow. Interestingly, the predominant theme across three of the four cases was redundancy as a contributor to flow (it was identified in Case A, Case C, and Case D). Additionally, in the case where diversity was identified as a disrupter to flow (Case B), redundancy as a contributor to flow was absent—suggesting, when examined from a complexity theory perspective, participants within Case B may not have experienced flow. Select literature on the concept of flow provides an interesting lens through which to discuss the findings related to flow.

The theory of flow comes from the work of Csikszentmihalyi and colleagues and originated in the 1960s (Csikszentmihalyi, 1988a). Initially, the concept of flow stemmed from psychology and the study of people who experienced intense engagement while performing actives such as hobbies (e.g., chess games) or sports (e.g., rock climbing) (Garland, 2006). Since the original work in psychology, the theory of flow has been applied in many disciplines, such as education in general (Garland, 2006), music education, (Custodero, 2002), and business (Vogt, 2005). Drawing from Csikszentmihalyi's work, Vogt (2005) defined flow as an experience one gets when engaging with a complex[11] activity. Specifically, to experience flow, one's skills must match the challenge, there must be a clear goal, and opportunities must exist to demonstrate contributions both individually and as a group (Vogt, 2005). Within this experience, one becomes intensely engrossed in the task (Vogt, 2005) and can often lose track of time (Csikszentmihalyi, 1988b), and, thus, experience flow.

These descriptions of flow can help us understand what participants reported occurring within some of the cases in my research (e.g., Case A, Case C, and Case D). It is important to note that despite flow being an individual and subjective experience (Csikszentmihalyi, 1988a), flow does contribute to the overall collective (i.e., system) and not only the individuals within it. For example, Mitchell (1988) described flow as a theoretical perspective useful in sociology:

> Conversation, for example, is sometimes embarrassed and halting when the roles of the participants are unclear or the definition of the situation is unresolved … there are also times when conversation progresses comfortably, when ideas are

[11] I am using the term "complex" in a literal manner and not to refer to complexity theory.

> exchanged directly, emotions are shared, and participants feel both that they understand and that they are understood. (p. 49-50)

In the above quotation, Mitchell is discussing how flow can contribute to or impede conversations as an argument to how flow is present in ordinary occurrences involving more than one individual. Consider my observations from Case B in light of Mitchell's description of flow in conversations. In Case B, I observed that the conversations were "choppy" amongst participants. Likewise, the participants reported "taking turns" talking as evidenced by the following quotations:

> *Once I started the conversation like with the sim doll and then introduced people…the others interact with the doll afterwards…nutrition it's not really, like, we don't really go hugely in depth in the nursing so like as soon as that came up (.) took control (B2).*
>
> *I found it weird because of (a) the simulation and (b) I was worried because we all have different personality types we would just be contradicting each other* (B3).

To use the words of Mitchell, the conversation in Case B was halting and the participants reported feeling unclear of the situation. It seemed that diversity disrupted flow.

Conversely, returning to Case A and Case D as examples of two cases where redundancy appeared to contribute to flow, the following two quotations illustrate what Mitchell is referring to as comfortable progression. A quotation from Case A:

> *Just on my own, like I felt my own comfort level so at first you know you are a little bit anxious and you are kind of thinking, like, oh, am I going to hit the right points, but then, um, we were able to laugh a bit with him and...(A1).*

And it just kind of flows (A2).

Ya! Like I thought it flowed well and well he...(A1).

When you say flow, what do you mean flow (Researcher).

Just, um, there were no awkward pauses where we were shuffling through our papers and he's like, well, what are you doing? What's happening next?

Everybody's responses were kind of natural and…(A1).

It was like a conversation (A3).

It really...it wasn't a forced…interaction really. I think it was a little more comfortable and we were able to deal with situations like where he asked about his dressing and we took a look at it.

A similar quotation from Case D:

I think we did generally pretty well. I feel like we played off each other (D1).

That is what I was going to say (D2).

What do you mean by played off each other? (researcher)

As a nursing student if we mentioned, like, going back to the fall, like, oh, you had another fall, why did you fall, and then coming from a pysch perspective, like, again, was that mental health wise, is that why he fell. Something like, you picked up little things that the other person would say and you could like play off, like if someone's speaking and you're like, oh, I want to add to that idea, and then you wait, and then you mention it again, so if I said something like, like with the life alert, like, like, pysch you could be thinking something completely different. Like you play and learn off each other…we didn't know everything about this case but

then you brainstorm and you pick up little things that maybe you could assume (D1).

Examining the above two quotations specifically, and the idea of redundancy as a contributor to flow within interprofessional education more generally, it becomes increasingly important to consider alternative ways of viewing interprofessional education. When we focus on the "container" metaphor of learning as McMurtry et al. (2016) have suggested most interprofessional education researchers have, we overlook the importance of interprofessional learning occurring socially through relationships. Instead, researchers (and educators) are overly focused on "up-skilling" individuals within a group using competencies at the expense of tending to factors, such as redundancy, that contribute to flow within a group—and presumably better learning opportunities as illustrated in the above quotations. Expecting students to easily apply knowledge developed in one context to other contexts is an unfair expectation (McMurtry et al. 2016). Instead, viewing interprofessional education through the lens of complexity theory, may assist educators and researchers in capturing the realities that participants experience—concepts such as diversity, redundancy, and flow have the potential to influence learning; thus, we must consider them in planning interprofessional education. To that end, in the next section, I offer several recommendations for educators working in interprofessional education.

Recommendations for Educators working in Interprofessional Education

Based on the findings from the case study, I offer recommendations for educators who are charged with supporting interprofessional education. It is noteworthy that much of the interprofessional education occurring in post-secondary education in Canada is

either extra-curricular or curricular but voluntary at different times. As such, the professional mix is often out of the control of the educator and unknown leading up to the session—making the level of difficulty and topics of the sessions challenging for learners. Nonetheless, I offer the following recommendations based on my findings:

1. Attempt to provide enough constraint (i.e., rules, structure, directions, etc.) so that students are oriented to what is expected of them (i.e., the objectives) but with enough flexibility so that students can engage with the case (through diversity and redundancy) and experience learning in different ways (self-organization and emergence). The appropriate balance of constraint and flexibility will vary based on the type of students participating (e.g., profession, level, experience with interprofessional education). Outside of an interprofessional education context, B. Davis et al. (2007) refer to this balance between constraint and flexibility as "liberating constraints" and educators interested in this idea may want to refer to their work. Within an interprofessional education context, McMurtry (2010) and Weaver et al., (2011) have used the term "enabling constraint."
2. Expect and cultivate redundancy within the interprofessional education session by including elements of commonality amongst the agents. In my cases, these included elements such as mental health, nutrition, finances, and mobility. Redundancy in my cases was cultivated by including these topics that many (not all) of the students would have encountered in their uni-professional education thus far. Redundancy within interprofessional education may support conversations, contribute to flowing discussions, and connect topics across

discussion. As illustrated, these discussions and conversations will self-organization and emerge depending on the student's themselves.

3. Expect and cultivate diversity within interprofessional education sessions by involving students from different professions, levels (e.g., junior and senior), and backgrounds. Additionally, include some topic areas that may not be covered in all professional programs (e.g., wound care, pain management, range of motion exercises). Sharing of diverse approaches can occur across year levels and professions.
4. Expect interprofessional education sessions to evolve in a non-linear fashion. In my cases, the cases had the same starting point (e.g., plan a discharge for a patient) but all proceeded in slightly different ways (e.g., different topics were discussed) and how students arrived at that ending varied. Although oversimplified, the trajectory was influenced by the type of students involved in the cases (their diversity) and how they interacted common areas within the cases (their redundancy). Interprofessional education is a complex system so the teaching method should reflect aspects of complexity theory.
5. Finally, assume a level of control that is decentralized. In the case studies that comprised my research, I was not in control despite being the only faculty member and most experienced person in the room. Instead, the participants involved in the cases, the students themselves, were in control of how the cases proceeded, what topics they discussed, and the plan of care for the simulated patient. As illustrated, the differing forms of control resulted in different topics being discussed, and presumably different learning to have occurred.

Additional and helpful recommendations exist in the literature for planning and conducting interprofessional education. For example, Boet et al. (2014) offered twelve practical tips for interprofessional education. Not surprisingly, the recommendations I offer overlap slightly with Boet et al. For example, we both suggest diversity of professions is important. However, the key difference between my recommendations and those available in the literature is that I am relying upon a certain and explicit theoretical perspective, complexity theory, to develop such recommendations and their recommendations appear to be based solely on practice. Interestingly, Boet et al. do overlap, at least superficially, with complexity theory by suggesting diversity, equity, and relevance are all important to consider. However, by offering recommendations based on a particular theory, I aim to provide the reader with an additional tool, the theoretical perspective and assumptions underlying them, to help determine if such recommendations may apply in a particular context.

Implications for Future Research

My research attempted to understand how interprofessional education occurs when viewed from a complexity theory lens. Although the findings offer some insight, clearly more research would be useful. First, questions remain if whether students who participate in interprofessional education sessions that integrate complexity theory in their design and implementation would practice interprofessional collaboration more effectively than those who participate in interprofessional education designed from a different, or no, theoretical perspective. As Estabrooks et al. (2006) noted, “theory matters because it is necessary in order to develop testable and probably useful

interventions" (p. 29)[12]. Likewise, McMurtry et al. (2016) recently argued complexity theory, among other similar theories, can help "explore how learning can be reframed in a manner that is better attuned to the complex realities of interprofessional practice" (p. 178). Research comparing the effects of different theories (e.g., complexity theory, adult learning theory, social contact theory, communities of practice theory) on interprofessional education design and outcomes is warranted. Moving forward, researchers should both test (through comparison of interventions based on different theories) and explore (through qualitative case studies) the effects of different theories on interprofessional education activities. Developing potentially useful approaches to interprofessional education that resemble the complex realities in which they are enacted should produce better outcomes for interprofessional education and collaboration, but this is yet to be proven and thus warrants further research.

Second, the results from my scoping review and case study do not answer the question of how complexity may be best suited for informing research in, more broadly, health services research and, more specifically, interprofessional education. My scoping review offered some examples of how researchers are using the theory. Those examples overlapped with how researchers are using the theory in education (e.g., B. Davis et al., 2007; Gallagher & Fazio, 2009). However, the appropriate approaches to using complexity theory in interprofessional education remain to be seen. For example, are diversity and redundancy the best concepts to use as lenses to analyzing data or, perhaps with a different methodology such as participatory action research, could self-

[12] The quotation from Estabrooks et al.'s (2006) refers to knowledge translation interventions. Interprofessional education and knowledge translation interventions are similar and it is feasible to generalize this quotation to an interprofessional education context.

organization and emergence be experienced and thus captured for study? As more researchers continues to grapple with complexity theory in interprofessional education, and more broadly health services research, more answers will emerge regarding how best to use complexity theory in these areas.

Third, is it possible to use complexity theory in a quantitative, or modeling, approach to better understand interprofessional education? Some authors have called for increased modeling (e.g., Sturmberg et al., 2014) and others have attempted to demonstrate such modeling (e.g., Pitkääho et al., 2014); yet, it remains to be seen how such modeling could be applied in an interprofessional education context. Quantitative approaches exist for measuring readiness for interprofessional education and outcomes of interprofessional education. A next step would be to develop a conceptual model of interprofessional education (or use an existing model), operationalize select variables of complexity theory and integrate them into the model, and begin testing such models to see how they apply in an interprofessional education context by using readiness and outcomes measures. For example, one could measure a group's readiness for interprofessional education, implement an intervention (i.e., interprofessional education activity), measure the outcomes of the interprofessional education, and subsequently measure concepts of diversity and redundancy within the group. From these measurements, one could develop a multiple linear regression model with outcome of the interprofessional education intervention as the dependent variable and diversity and redundancy as the independent variables, while controlling for readiness for interprofessional education and other variables (e.g., skill-mix, experience, etc.). My dissertation work suggests that diversity and redundancy influence interprofessional

learning—quantitative modeling may add further understanding to the degree of diversity and redundancy required to influence interprofessional learning.

Fourth, and finally, research related to how complexity theory could be used to design interprofessional education sessions, from the outset and from the perspective of those designing the sessions, would be a useful addition to the literature. I am aware of a few studies (e.g., Cooper & Geyer, 2008; Cooper & Spencer-Dawe, 2006; Jorm et al., 2016; McMurtry, 2010) examining the use of complexity theory in an interprofessional education, but, to my knowledge, no further research has been published. Clearly, if we are to accept that complexity theory is a useful tool for informing such research, we must develop an evidence base for how the theory could be used on a practical level by those offering interprofessional education. Building on the work of others, a potential line of inquiry would be to explore how a longitudinal approach to research may influence the concepts of complexity that are potentially useful. In my research I was unable to detect aspects of self-organization and emergence within my data yet diversity and redundancy were present. I hypothesized, based on comparison to other researchers who have successfully used such concepts in their work (Colon-Emeric, 2006; Fazio & Gallagher, 2009; Weaver et al. 2011), that the length of the experience being studied and the length of the data collection period matter in terms of what concepts of complexity theory may be used or detected. If diversity and redundancy precede and support emergence and self-organization, it is logical that to study emergence and self-organization, one must ensure sufficient time occurs during data collection (and the phenomena of interest). Likewise, an inductive approach to analysis, as opposed to an apriori, would allow for concepts of complexity to emerge that may only be detectable over a longer study period.

Limitations

In this section, I will address limitations of my research. As two distinct studies comprised my doctoral research, I will separate the limitations sections into two subsections and offer five limitations for each. I will follow this with a discussion of limitations of the overall dissertation.

Limitations of the scoping review. The limitations of my scoping review are not uncommon in scoping review approaches. The first relates to my search terms. To ensure I captured the complexity literature, a body of literature that is not yet defined with a common set of terms, I used a broad approach and included certain terms that some may argue are not synonymous with complexity theory (e.g., Chaos Theory, Complex Responsive Process Theory). One outcome of this broad approach was that many articles were located by the initial search, but not all of them were included in the review; thus the first level screening was cumbersome.

Second, I only included studies published in English. Such language restrictions are a common limitation in scoping reviews. The outcome of a language restriction is unknown (Garg et al., 2008) and it is possible that we missed some important articles.

Third, I undertook this scoping review in a solitary manner. In other words, although my supervisor and committee members were available to assist at certain points, certain decisions were made in isolation. Decisions related to search-strategy, inclusion/exclusion criteria, data extraction, and data analyses are usually made through discussions with team members. As such, there is risk that my views influenced a great deal of the review and the views of others would have strengthened the approach. Nonetheless, when I encountered difficult decisions, I consulted my supervisor and

decisions were reached based on consensus (e.g., whether to exclude quality improvement articles).

Fourth, because I formulated a list of parent concepts and grouped all of the concepts from the literature within that list, I was forced to rely on my interpretations of the concepts being discussed in the literature. Although this is a limitation inherent in all research, and particularly reviews, it is possible I interpreted certain concepts incorrectly and thus grouped them incorrectly, leading to questionable findings. In a short commentary on how their influential complexity theory articles may have been misinterpreted by researchers in health, Greenhalgh et al. (2010) clearly placed the onus on the researcher when they stated: "Numerous other authors over the years have misinterpreted, misrepresented or misapplied our augments, but we cannot be held responsible for this" (p. 116). As such, I am explicitly identifying my interpretations as a limitation in my scoping review—albeit an unavoidable limitation.

Finally, I did not assess the methodological quality of included studies. Methodological quality assessment of included studies in scoping reviews is an area of recent debate (Daudt et al., 2013; Pham et al., 2014). Had I assessed methodological quality, I could have used the findings in a couple of ways. First, I could have excluded studies based on quality. Excluding studies based on quality would have strengthened some of my conclusions because the weaker studies would have been removed before my analysis. Second, I could have offered additional findings on the overall methodological quality of the literature that used complexity theory in health services research. Nonetheless, methodological quality assessment of studies was not part of the Arksey and O'Malley (2005) process I followed.

Limitations of the case study. Similar to the scoping review, there were a few limitations in my case study worth mentioning. First, although the interprofessional education activities were similar in duration to what is normally offered at the institution where the research occurred, the duration was relatively short (3 hours) and not typical of what would be offered for interprofessional education occurring within a curriculum (e.g., over the course of a semester). Had the activity been longer, or held over several sessions, different results may have occurred related to complexity theory. For example, as I mentioned in Chapter 3, I was unable to capture sufficient instances of self-organization and emergence. I hypothesized that these concepts elusive in my data because they may take longer to occur within a group. This hypothesis seems logical given the idea that diversity and redundancy support self-organization and emergence. More research is needed to explore if duration length influences how complexity concepts occur.

Second, I used an a priori codebook (Crabtree & Miller, 1999) during the initial classification stage. Although Crabtree and Miller support this approach, they recommend an option of having an "open code" category to capture themes or concepts that emerge outside the a priori codes. I initially attempted the open code approach, but the amount of open coded data became unmanageable. Thus, a limitation to my research is that it relies solely on deductive categorization, followed by inductive analysis, as opposed to a cyclical deductive-inductive approach.

Third, I did not perform member checking. Member checking is an important step for establishing rigour (specifically credibility) in qualitative case study research and,

ideally, involves participants reviewing transcripts prior to data analysis to confirm accuracy (Houghton, Casey, Shaw, & Murphy, 2013).

Fourth, and finally, there was limited research on how complexity theory could be used to explore interprofessional education, and, thus, I relied on findings from my scoping review on how health services researchers have used complexity theory in their research, in addition to a portion of the findings from my literature review. Although interprofessional education research forms a subset of health services research, there may be differences between the bodies of literature that make generalizing the findings problematic. Further, the variability in how researchers have used the theory did not offer clear guidance in how the theory (or what parts of the theory) should be used. As a novice researcher and a relatively new reader of complexity theory literature, my understanding of complexity theory developed over the course of the research as I was exposed to additional perspectives. I elaborate on this limitation in the following section as it has implications for the overall dissertation.

Reflections on the limitations of the dissertation. Although the title of this section appears negative, I wrote this section in a positive light. It is the last section I wrote—and I did so after successfully defending my dissertation. My thoughts on my dissertation are summarized perfectly by my doctoral supervisor, Dr. Darren Stanley, in his own dissertation reflection:

> It makes me uncomfortable putting this work "out there" knowing—or rather believing—that inevitably there will be parts of this dissertation that sound incredulous or troubling. Indeed, even for myself right now, there are bits that I

> no longer agree with or that I would qualify rather strongly. Constant questioning and on-going conversations will do that in the midst of putting a piece of writing together like this. (Stanley, 2005, p. 156-157)

It makes me uncomfortable putting my work "out there" also. There are three related limitations to this dissertation that I am aware of—and likely a few more that I am not aware of. The first two relate to the fit between the scoping review and the case study. The third relates to the fit between the theory used and the phenomenon studied.

The first limitation of this dissertation is the fit between the scoping review and the case study. Specifically, at the outset of my doctoral work, I aimed to conduct a scoping review as a means of informing a case study. I was drawn to this approach because I wanted to immerse myself in two distinct, yet complementary, methodologies. Further, I envisioned the scoping review as a means for better understanding aspects of complexity theory and how complexity theory could be used in research.

My original plan was to conduct a scoping review on how complexity theory had been used in interprofessional education research to inform my case studies. However, at the start of my doctoral work, I was aware of only four publications reporting on three studies (Cooper & Spencer-Dawe, 2006; Cooper et al., 2005; McMurtry, 2010; Weaver et al., 2011) that used complexity to study interprofessional education, and the studies varied on their approach, focus, and use of complexity. Based on the heterogeneity and small sample, I concluded there was insufficient literature to conduct such a scoping review. Furthermore, during the course of my doctoral work, one more study was published (Jorm et al., 2016).

I made the decision to broaden my scoping review to study how complexity theory had been in used in health services research—an area where I knew more research existed. Interprofessional education research is a subset of health services research, and, thus, I assumed similarities between interprofessional education research and health services research—I question this assumption now. Although I combined the results of my scoping review with findings from my literature review, most notably the work of Davis and colleagues (B. Davis and Simmt, 2003; B. Davis and Sumara, 2006; Davis et al., 2007), McMurtry (2010), and Weaver et al. (2011), I could have improved the overall dissertation by attending to a better fit between the complexity theory and interprofessional education literature and my own case study. I could have broadened my scoping review search strategy to include interprofessionalism specifically or included health profession students in my scoping review. I made the decision narrow the focus of the scoping review, but, in hindsight, I focused the scoping review away from the case study topic.

Second, related to the fit between the scoping review and the case study, I approached my dissertation with the aim of learning two methodologies as opposed to letting the phenomena of interest guide my methodology. Any fundamental research textbook suggests that the research question and the phenomena under study should direct the researcher to the methodology and methods. In my dissertation, I let the methodology (more accurately, my desire to conduct a scoping review) guide my focus, which resulted in a disconnect between my scoping review and my case study. In hindsight, I should have either broadened the scoping review or expanded my case study and abandoned the scoping review to focus the dissertation solely on interprofessional education. Had I done

so, I perhaps would have expanded the number of categories within the cases and approached the analysis similar to Weaver et al., (2011) using additional conditions thought to contribute to collective learning.

Third, I was asked a very insightful question by one of my committee members—a question I could not answer. She wanted to know about using a theory that defies definition to study a phenomenon that is poorly understood. At the outset of my work, reading literature that suggested there is "no generally accepted statement of what complexity theory is or how complex something must be to come with the ambit of complexity theory" (Nunn, 2007, p. 378) and that "learning with, from, and about each other, as articulated in the definition and even in the principles, has not been conceptualized and described fully enough to effectively inform curriculum development and evaluation of interprofessional learning" (Bainbridge & Wood, 2013, p. 453) intrigued me. At the conclusion of my work, I believe I may have struggled with such ambiguity and could have improved the work by consolidating the literature that used complexity theory to study interprofessional education—and stayed within this literature in an effort to build upon it. Instead, I swayed to the health services literature. To answer the original question, using an undefined theory to study a poorly understood phenomenon is possible if one draws on the work of those who have done so—something I could have improved upon in this dissertation. Nonetheless, I have learned from these oversights, or opportunities, during my doctoral work.

Conclusion

Interprofessional education is a necessary component to educating health professionals. Not only is interprofessional education a requirement of many regulatory and professional bodies (e.g., College of Nurses of Ontario, Royal College of Physicians and Surgeons), interprofessional education is thought to lead to interprofessional collaboration and, ultimately, better care. Knowing how to best offer interprofessional education should be a key concern for educators in all health professions. Unfortunately, although some literature offers guidance, little is known of how best to conduct interprofessional education.

My research attempted to contribute to our understanding of how to support interprofessional education. I examined how health services researchers used complexity theory and conducted a case study of how interprofessional education occurs from a complexity theory perspective. My research adds to our understanding of how health services researchers are using complexity theory and how educators involved in interprofessional education may want to design and offer interprofessional education.

Health services researchers are using complexity theory in a variety of ways—and given the newness of complexity theory to health and social sciences settings, variability is expected. As more research is conducted, a better understanding of how complexity theory may look and work within a health and social sciences setting will emerge.

Interprofessional education exhibits elements of diversity and redundancy, key concepts of complexity theory that likely support self-organization and emergence. Clearly, I am hypothesizing that self-organization and emergences exists within interprofessional education, but if interprofessional education is indeed a complex

system, they must. Regardless, in my cases, diversity appeared to act as a foundation for interprofessional learning to occur through interaction and sometimes to disrupt flow. Redundancy appeared to contribute to flow and to act as a connector within interprofessional education. Educators involved with interprofessional education may want to consider some of these concepts related to complexity theory as a way to move from viewing interprofessional education as a group of individuals and more toward viewing interprofessional education as a learning collective.

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APPENDIX A

Sections of the Interprofessional Education Simulation

Duration	Section	Expectations of Participants
15 minutes	Introduction	Participants will be welcomed, introductions will occur, informed consent will be signed, information sheet for research will be distributed, incentives will be distributed, and a general orientation to the simulation suite provided by the researcher.
15 minutes	Overview of the Canadian Interprofessional Health Collaborative Competencies	Participants will be introduced to four Canadian Interprofessional Health Collaborative Competencies (patient centered care, communication, collaborative leadership, and role clarification) by the researcher. This will include a group discussion of each competency using the material provided on the Canadian Interprofessional Health Collaborative website: http://www.cihc.ca/files/CIHC_IPCompetenciesShort_Feb1210.pdf
30 minutes	Pre-simulation Session (Stage A)	As a group, participants will review a written case scenario entitled 'Discharge Mr. Sampson' (see below) and discuss written questions as a group (see below) designed to integrate the four interprofessional education competences introduced previously. This will also prepare participants for the simulation session (Stage B). This session will be video-recorded and facilitated by the researcher.
30 minutes	Simulation Session (Stage B)	Participants will interact with a manikin (patient simulator). An experienced operator at a computer station in an adjacent room will control the manikin. The researcher will be the voice of the manikin and will be able to hear and see the participants as they interact with the manikin. This session will video-recorded.
60 minutes	Debrief/Focus Group (Stage C)	Participants will participate in a focus group discussion immediately following the simulation. The Focus Group Questioning Route was reviewed and approved in my original ethics application. I am not requesting amendments to the general questioning route This session will be audiotaped.
15 minutes	Wrap-up	Extra time purposely allotted. Participants will be thanked for their time and any questions will be answered.

APPENDIX B

Case and Guiding Questions for Stage A: Pre Simulation

Objectives

Students will integrate competencies of interprofessional education (role clarification, patient centered care, communication, collaborative leadership) into the care of a simulated patient using a written-case scenario and simulation experience.

Background

Mr. Sampson is a 65-year old man who is being discharged from hospital in the next few days following a repair of a broken hip he sustained from a fall. His fall occurred when he was at home doing the laundry in his basement. He was transferred to Thunder Bay from a small outlying community where he lives with his wife in their own home. Their home community has a Family Health Team (community health centre) but not a hospital. They have a son and a daughter who both live in Southern Ontario. Mr. Sampson reports he is active in the community and enjoys curling in the winter and gardening in the summer. They survive on a small pension and report: "we have just enough money for how we like to live".

Mr. Sampson is otherwise healthy but he has been losing weight and becoming weaker over the past 6 months. He thinks his diet is "okay". He has no other illness and takes no medications. He visits his family doctor once a year. His wife has diabetes and manages it with medication and some lifestyle modification.

Mr. Sampson is anxious about being discharged home. He is worried about his wife assisting with his care as he recovers, how he will manage his pain and dressings, and how he will pay for any modifications required to his home related to his recent injury. He has received some teaching while in the hospital and "thinks someone will be coming to the home to take a look at it". He has been adamant while in the hospital that he "will not go into a long term care home". There is no long term care home in their home community and the closest one is approximately 75 km by highway.

He will be discharged with some mobility aids and aids to daily living (i.e., walker, raised toilet seat). He is unsure if these items will be covered under his health coverage. Additionally, the Community Care Access Centre will arrange for someone to visit his home and complete a home assessment however there is a waiting period.

Your group is to have a short discharge planning meeting (pre-simulation) and then meet with Mr. Sampson (simulation) to discuss any issues he may have related to discharge.

1. Working as a team, identify four priority areas to explore with Mr. Sampson prior to discharge. Discuss why you will focus on these areas and not other areas.

2. Are there any areas that Mr. Sampson will need addressed that are not dependent upon interprofessional collaboration? In other words, are there areas that one profession alone can address prior to his discharge?

3. From the areas you identified in #1 and #2, separate them into short and long-term issues. Develop a plan of care for each of the priority areas. How does the need for different professionals change across time?

4. How your team will handle the absence of other professions? Are there some issues that you anticipate can be handled by other professions?

5. How will your team ensure patient-centered care is maintained during your interaction with Mr. Sampson and during the planning of his care?

6. Is there any other planning that needs to occur before you go in and meet with Mr. Sampson?

APPENDIX C

Template for Stage B: Simulation

Approximate Timing	Manikin Actions	Expected Participant Activity	Possible Cues
1-5 minutes Introductions	Heart rate 106, blood pressure 120/80, respiratory rate 16, oxygen saturation 95%. Lying flat in bed. Continually verbalize anxiety about going home. Starting comment: "wow, there are so many people. I hope you are all here to tell me I can go home."	Participants come into room. Introduce themselves. Begin to speak with Mr. Sampson about discharge plans. Notice heart rate is slightly elevated.	Who are all you people and what do you do? When will I be sent home? Why do I need to see so many people? Isn't it the doctor who needs to send me home? What do you all do? Who is in charge?
6-10 minutes Anxious about discharge	Heart rate 110 Respiratory rate 18. No other changes. Starting comment "I'm really really worried about being sent home. I'm not sure I'm ready but I want to get out of here."	May raise head of bed and ensure patient is comfortable in bed. Participants will begin to question Mr. Sampson about his worries related to being discharged.	When asked by participants provide a list of worries related to being discharged (pain control, mobility, caring for wife, costs associated with any new devices, activities of daily living, ability to continue with leisure activities, when the home visit may occur to assess his house. Continue answering questions from participants and engage in conversation directed by participants but ensure some of the worries noted above are stated.

11-15 minutes Exploration of discharge	Heart rate 100 Respiratory rate 14. No other changes. Starting comment: "I'd like it a lot if we could talk more about how I might manage at home....what are all of the supports I will need and who will help. What do I do if things aren't working"?	Participants will begin to explore in more detail some of the worries about being discharged. Participants may begin to formulate plans for addressing Mr. Sampson's concerns. These plans will come from Stage A discussion.	Continue engaging with participants. Continue asking about details about all of the plans. Try to get participants to discuss their (and other professionals') roles in his care. Focus on the roles of the professionals in the simulation. Engage participants in discussion about what will occur if he is not managing at home. Again, focus on roles and scopes of practice of the professionals in the room. If conversation is slowing down, mention that his brother was discharged from hospital with a broken hip several years ago and was then placed in a long-term care facility. Talk about wishes to remain out of long-term care.
16-25 minutes Discussion about hip pain and discovery of dressing	No changes to vital signs. "I am having some pain on my hip. Maybe more than yesterday. I just didn't want to say anything because I want to get out of here. Could one of you look at it".	Participants will assess this patient's hip. They will notice the dressing that has visible wet blood soaking through. Depending on the mix and level of students the assessment will vary. Assessment could involve looking under the dressing, range of motion of the leg, and/or pain assessment.	Ask specifically to visually look at hip if needed. Once students assess the dressing and make a plan of how to address it, ask about whether this will affect the plan to be discharged. Continue to question participants about discharge. Engage with students about the type of assessment they are doing. Ask questions about what they are doing and the rational.

		Depending on the mix/level of the students they will make a plan related to the dressing.	
26-30 minutes Ending	No changes to vital signs “I do feel a lot better having spoken with all of you. Thank you”.	Participants will sense the ending of the simulation and ask a few final closing questions.	Engage with participants but keep suggesting they have made him feel much better. If needed cue fatigue and state “I’m tired and feel like I need a bit of a rest now”.

APPENDIX D

Recruitment Poster

Seeking Participants for Interprofessional Education Simulation Study

I am looking for participants enrolled in health related programs to take part in a study exploring interprofessional education using simulation.

Participation will require three hours of your time and will include
a short orientation to interprofessional collaboration, a video-taped interprofessional education simulation, and an audio-taped group interview.

Participants will receive a $20 gift card to a local chain restaurant. Participants will also be provided light refreshments during the interview.

If interested in participating please contact:
David Thompson at Thomps1l@uwindsor.ca

This research has received clearance from Lakehead University and University of Windsor ethics boards.

APPENDIX E

Classroom Presentation

Hello. My name is David Thompson and I am a PhD candidate at the University of Windsor in the Joint Educational Studies program. I am here to invite you to participate in a research study I am conducting. This research will contribute to my doctoral work. It is titled: Interprofessional Education Viewed from a Complexity Theory Perspective.

As you may know, interprofessional education occurs when students from at least two different professions learn with, from, and about each other to improve patient or work outcomes. Research suggests that interprofessional education works to improve interprofessional collaboration. While we know interprofessional education is a good thing, not much is known about how best to design interprofessional education activities. My research aims to explore interprofessional education using some concepts from complexity theory. Complexity theory offers a perspective for examining and explaining things that occur across many different professions and disciplines. It suggests that new things can occur as a result of very small changes occurring at many levels. These changes often happen in the absence of any outside control and are often unpredictable. Think of a flock of birds. The birds flock together but no one bird is controlling the overall flock. Instead, each bird altars it's flying pattern based on what the bird next to it is doing (or not doing). This is one way of looking at a flock of birds and thinking about, perhaps even explaining, why they behave as they do. This is what I plan to use complexity theory to do in the context of interprofessional education. Several researchers have begun to use complexity theory in health and education.

The purpose of the study is to explore interprofessional learning using parts of a new theory called complexity theory. To accomplish this, I would like to do two things. Frist, I would like to video-record groups of students participating in interprofessional education using a patient case and a simulation manikin. Video-recording will allow me to observe and analyse interprofessional learning using concepts from complexity theory. Second, I would like to conduct audio-recorded group interviews immediately following the simulation. The time commitment is 2.5-3 hours. The research ethics boards at both University of Windsor and Lakehead University have approved this research.

I anticipate no potential risks or discomforts by participating in this research. A possible benefit is that you will experience an interprofessional education simulation and a focus group. This experience could foster an interest in and appreciation of interprofessional education and/or research. This research has the potential to contribute to our knowledge of how interprofessional learning occurs in interprofessional education activities. This knowledge will assist us in designing future interprofessional education activities. You will receive a $20 gift card to a local restaurant. Additionally, refreshments and healthy snacks will be served at the focus groups. If you are interested or have questions please email me using the address on the information sheet I am handing out

Are there any questions?

APPENDIX F

Lakehead University Research Ethics Board Certificate

Lakehead UNIVERSITY

Research Ethics Board
t: (807) 343-8283
research@lakeheadu.ca

October 14th, 2014

Principal Investigator: Dr. Darren Stanley
Co-Investigator: Mr. David Thompson
External
University of Windsor

Dear Dr. Darren Stanley:

Re: REB Project #: 049 14-15 / Romeo File No: 1464030
Granting Agency: N/A
Granting Agency Project #:N/A

On behalf of the Research Ethics Board, I am pleased to grant ethical approval to your research project titled, "Interprofessional Education Viewed from a Complexity Theory Perspective".

Ethics approval is valid until October 14th, 2015. Please submit a Request for Renewal form to the Office of Research Services by September 14th, 2015 if your research involving human subjects will continue for longer than one year. A Final Report must be submitted promptly upon completion of the project. Research Ethics Board forms are available at:

https://www.lakeheadu.ca/research-and-innovation/forms

During the course of the study, any modifications to the protocol or forms must not be initiated without prior written approval from the REB. You must promptly notify the REB of any adverse events that may occur.

Completed reports and correspondence may be directed to:

Research Ethics Board
c/o Office of Research Services
Lakehead University
955 Oliver Road
Thunder Bay, ON P7B 5E1
Fax: (807) 346-7749

Best wishes for a successful research project.

Sincerely,

[redacted]

Dr. Lori Chambers
Chair, Research Ethics Board

APPENDIX G

University of Windsor Research Ethics Board Certificate

REB Clearance

ethics@uwindsor.ca <ethics@uwindsor.ca> Thu, Jul 31, 2014 at 3:41 PM
To: "Mr. David Thompson (Primary Investigator)" <thomps1l@uwindsor.ca>, "Dr. Ronald Stanley (Supervisor)" <DSTANLEY@uwindsor.ca>
Cc: ethics@uwindsor.ca

Today's Date: July 31, 2014
Principal Investigator: Mr. David Thompson
REB Number: 31695
Research Project Title: REB# 14-121: Interprofessional Education Viewed from a Complexity Theory Perspective
Clearance Date: July 31, 2014
Project End Date: December 01, 2015
Milestones:
Renewal Due-2015/12/01(Pending)
Renewal Due-2015/09/07(Pending)

This is to inform you that the University of Windsor Research Ethics Board (REB), which is organized and operated according to the Tri-Council Policy Statement and the University of Windsor Guidelines for Research Involving Human Subjects, has granted approval to your research project on the date noted above. This approval is valid only until the Project End Date.

A Progress Report or Final Report is due by the date noted above. The REB may ask for monitoring information at some time during the project's approval period.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the REB. Minor change(s) in ongoing studies will be considered when submitted on the Request to Revise form.

Investigators must also report promptly to the REB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

Forms for submissions, notifications, or changes are available on the REB website: www.uwindsor.ca/reb. If your data is going to be used for another project, it is necessary to submit another application to the REB.

We wish you every success in your research.

Alan Scoboria, Ph.D.
Chair, Research Ethics Board

Lambton Tower, Room 1102 A
University of Windsor
519-253-3000 ext. 3948
Email: ethics@uwindsor.ca

APPENDIX H

Participant Information Letter

LETTER OF INFORMATION FOR CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: Interprofessional Education Viewed from a Complexity Theory Perspective

You are asked to participate in a research study conducted by David Thompson. This research will contribute to David Thompson's doctoral dissertation.

If you have any questions or concerns about the research, please feel to contact David Thompson's Doctoral Supervisor, Dr. Darren Stanley, at (519) 253-3000 ext. 3817

PURPOSE OF THE STUDY

To explore interprofessional learning using parts of a new theory called complexity theory.

PROCEDURES

If you volunteer to participate in this study, you will be asked to:

1. Participate in a short discussion about interprofessional collaboration competencies lasting approximately 30 minutes.

2. Consent to being video-recorded while discussing a case-scenario and participating in a simulation with other participants related to interprofessional education lasting approximately 60 minutes.

3. Consent to participating in an audio-recorded focus group interview with peers lasting approximately 60 minutes.

POTENTIAL RISKS AND DISCOMFORTS

There are no potential risks or discomforts beyond that of the risk of mild anxiety when working within a group.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

Participants will have the opportunity to augment curricular exposure to interprofessional education and research. This experience could foster an interest in and appreciation of research and/or interprofessional education. This research has the potential to contribute to our knowledge of how interprofessional learning occurs in interprofessional education activities. This knowledge will assist us in designing future interprofessional education activities.

COMPENSATION FOR PARTICIPATION

Each participant will receive a $20 gift card to a local chain restaurant. Additionally, refreshments and healthy snacks will be served during the focus group interview.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. All data will be secured on the Lakehead University or University of Windsor campuses. Only members of the research team will have access to the data. Data will be stored for five years and then erased. Data will be stored on a secure password protected laptop or a password protected memory stick. The laptop or memory stick will be stored in a locked cabinet in a locked office at Lakehead University. The focus group is a group event. This means that while confidentiality of all the information given by the participants will be protected by the researchers themselves, this information will be heard by all the participants and therefore will not be strictly confidential.

PARTICIPATION AND WITHDRAWAL

The investigator may withdraw you from this research if circumstances arise which warrant doing so. Circumstances that could lead to the investigator terminating participant involvement include participant difficulty managing stress levels or unforeseen extenuating events. You are able to withdraw from the research at anytime without penalty. If you withdraw you will be able to keep the gift card. Because the video recordings and focus groups are group activities, if you withdraw after the interprofessional education activity you cannot withdraw the video data. Likewise, if you withdraw after a focus group, you cannot withdraw the information shared within the focus group.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE PARTICIPANTS

A summary of the research findings will be made available on the University of Windsor Research Ethics Board website and David Thompson's dissertation will be made available on the Proquest Dissertations database.

Web address: http://www.proquest.com/products-services/dissertations/
Date when results are available: January 2016

SUBSEQUENT USE OF DATA

These data may be used in subsequent studies, in publications and in presentations.

RIGHTS OF RESEARCH PARTICIPANTS

If you have questions regarding your rights as a research participant, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario, N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

_____ _____

Signature of Investigator Date

APPENDIX I

Interview Protocol

Opening Question

1. Tell me a little about your experience working through that simulation. How did it go?

Introductory Questions: General Questions about Interprofessional Education

2. What are the words that come to mind when you hear the phrase 'interprofessional education'?

3. Think back in your education to date. Please **describe** your experience learning within an interprofessional education context.

   Possible Probes: Did the learning differ from a non-interprofessional education context?

Transitions Questions

4. Interprofessional education is about learning with, from, and about each other. Please describe what it means to you to learn with, from, and about each other?

   Possible Probes: How did you know you were learning with, from, an about?

5. Describe how learning with, from, and about each other occurred in the simulation you just participated in.

Key Questions: Features and Attributes of Complexity Theory

5. Looking back at this simulation, can you describe a situation where you felt that you learned something different than others in the group or do you feel that all members of the group learned exactly the same thing? Explain how this may have occurred (e.g., did conditions contribute to your learning that others may not have experienced)

6. Describe a situation from the simulation where you felt you may have contributed to others learning. Did the conditions that facilitated your learning help you to contribute to the learning of others? What made this possible?

7. Explain how you felt your group navigated periods/instances of uncertainty. Describe how your understanding of interprofessional collaboration contributed to navigating the uncertainty.

   -Probe: Was there a natural leader?

8. Describe how you felt your group learned together? Explain how you think this occurred.

9. When you review the Learning Objectives written on the paper case (provide to participants),

Ending Questions

9. If a teacher approached you and asked you how to best support learning during interprofessional education, what advice would you give?

10. I am going to summarize the key points of our discussion now. I would like you to listen carefully and let me know if I correctly described what was said. <3-4 minute summary>. Is there anything that you didn't get a chance to say or that was not included in my summary?

VITA AUCTORIS

David Scott Thompson was born in 1977 in Thunder Bay, Ontario. He graduated from Hillcrest High School in 1995. From there he went to Lakehead University where he obtained a Bachelor of Science in Nursing in 2000. He worked as a Registered Nurse in Ontario and Alberta before obtaining a Master of Nursing from the University of Alberta in 2006.