INVESTIGATING WORK-RELATED SERENDIPITY, WHAT INFLUENCES IT, AND HOW IT MAY BE FACILITATED IN DIGITAL ENVIRONMENTS

by

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This thesis is dedicated to Madeleine.

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ABSTRACT

Serendipity is a popular word that captures a rich phenomenon with potentially far-reaching implications from a personal to global level. Serendipity is associated with revelations, discoveries, life events, and innovations, both big and small, and the lack of consensus on its definition reflects this breadth of meaning. Serendipity is defined in this research as an unexpected experience prompted by an individual's valuable interaction with ideas, information, objects, or phenomena. While efforts are being made to facilitate serendipity in digital environments (e.g., websites, databases, search engines), we know very little about the complex interaction between the individual and the environment and what actually facilitates serendipity.

In three phases, this thesis investigated how individual differences and environmental factors influence work-related serendipity and how serendipity may be facilitated in digital environments. Phase 1 explored serendipity through semi-structured interviews with 12 professionals and scholars. Based on findings from Phase 1, in Phase 2 a serendipitous digital environment scale to measure how well a digital environment supports serendipity was developed, assessed, and honed though an expert review by eight researchers and a web-based survey of 107 university students. Phase 3 employed a web-based survey of 289 professionals and scholars. Through exploratory factor analysis, the serendipitous digital environment scale was refined and assessed. Using multivariate analyses, relationships were explored between serendipity, the underlying factors of the serendipitous digital environment scale, type of digital environment, creative environment perceptions, locus of control, extraversion, and openness to experience.

My research found that the type of digital environment influences the frequency of serendipity, which in turn shares a relationship with three factors of the serendipitous digital environment scale – *enables connections*, *trigger-rich*, and *leads to the unexpected*. Furthermore, results indicate that individuals' level of extraversion influences perceptions of serendipity in general. This research contributes to our knowledge of information seeking and use through findings that confirm and augment previous models of serendipity through the identification of what influences serendipity. This research also underscores the potential to design for serendipity in digital environments and provides a tool for developers to assess the serendipitous nature of their systems.

LIST OF ABBREVIATIONS USED

CEP	Creative Environment Perceptions
CONN	SDE-Enables Connections
DE	digital environment
EFA	exploratory factor analysis
EXTRA	Extraversion
HIGH	SDE-Highlights Triggers
IE	information encounter
IIA	incidental information acquisition
IIS&R	interactive information seeking and retrieval
IR	information retrieval
IT	information technology
LCB	Locus of Control of Behaviour
OAI	opportunistic acquisition of information
ODI	opportunistic discovery of information
OPEN	Openness to Experience
RQ	research question
SDE	serendipitous digital environment
SIS	serendipity in information seeking
TRIGG	SDE-Trigger Rich
UNEX	SDE-Leads to the Unexpected

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CHAPTER 1. INTRODUCTION

1.1 Overview

Both the existence and value of serendipity are widely recognized in a multitude of domains of human inquiry and experience. Julian Luxford, a medieval music historian, for example, stumbled upon marginalia referencing Robin Hood, a topic outside his area of expertise (Sims, 2009). Luxford knew just enough to recognize that he had found something rare and important and he went on share this treasure with the historical community (Luxford, 2009). Perhaps the most famous example of serendipity is Fleming's discovery of penicillin. While investigating bacterial inhibitors by conventional scientific methods, Fleming accidentally contaminated bacteria and stumbled upon an effective antibiotic (Roberts, 1989). As twentieth century journalist Arthur Koestler (1964) once noted, "The history of discovery is full of such arrivals at unexpected destinations, and arrivals at the right destination by the wrong boat" (p. 145). Luxford's example captures Koestler's "unexpected destinations" analogy while Fleming's illustrates the "wrong boat." Though very different, the examples share qualities that make them serendipitous: *unexpectedness, insight,* and *valuable, unanticipated outcome* (Makri & Blandford, 2012a). In the field of management, for example, organizations stand to reap the benefits of valuable, unanticipated outcomes if conditions that precipitate serendipity are fostered (Cunha, 2005). Companies like Google design buildings and rearrange furniture to maximize the potential for serendipitous encounters among co-workers (Lindsay, 2013). Creating mechanisms to support serendipity in digital environments such as work intranets, websites, and databases also reflects this desire to nurture serendipity, but we know very little about the complex interaction between the individual and their environment and what actually facilitates serendipity.

This PhD thesis explores work-related serendipity and the examples introduced above – relating to Robin Hood and penicillin – are good illustrations of scholarly and scientific work-related serendipity. Serendipity is situated in this thesis as an experience that has a discernable, underlying process and this process is evident across diverse serendipitous experiences that are bound by common types of events, activities, thought processes, outcomes, and perceptions. This research is primarily concerned with the characteristics

of digital environments that have the potential to support serendipity as well as personality traits such as openness to experience (Lee & Ashton, 2004) that may also influence serendipity and how an individual perceives the experience.

As a starting point, I investigated how the process of work-related serendipity unfolds through the experiences of a variety of academics and professionals. From this exploration of serendipitous experiences as well as a review of the prior research I selected characteristics of the individual and the environment that I wanted to explore further and developed a preliminary self-report questionnaire – the serendipitous digital environment (SDE) scale. The serendipitous digital environment scale is a multifaceted scale. The scale's facets are designed to capture the characteristics or features of an environment reliant on technology that has the potential to facilitate serendipity. Using qualitative and quantitative methods, I assessed the content validity of the serendipitous digital environment scale and refined it. Furthermore, I developed a self-report serendipity questionnaire designed to capture how frequently serendipity occurred in general, in digital environments, and in a specific digital environment. Through a large, web-based survey I examined the relationships between multiple variables:

- Underlying factors of the serendipitous digital environment (SDE) scale;
- Serendipity;
- Type of digital environment (website, intranet, database, search engine, and social media);
- Extraversion;
- Openness to experience;
- Locus of control of behaviour; and
- The creative work environment.

This first chapter frames the research problem by exploring why serendipity and particularly why support for serendipity in digital environments merit investigation. The statement of purpose that guides this research is provided as well as a summary and a description of the thesis structure.

1.2 Why Serendipity Matters

In her Rice Centennial Lecture, Shirley Ann Jackson, President of the Rensselaer Polytechnic Institute in New York spoke of the importance of serendipity:

> When we fund basic research, we are funding serendipity. Even a sober, frugal, post-recession United States must invest in serendipity, because without it, there is no vitality in the innovation ecosystem. Indeed, there is no innovation. (Jackson, 2012, n.p.)

In the context of business and research, serendipity is often credited with contributing to innovation (Campanario, 1996; Jackson, 2012), the acceleration of business growth (University of Canterbury, 2013), and the development of new research directions (Foster & Ford, 2003). Thus, in the big picture, it is important to understand serendipity, what influences it, and what may facilitate it. While the impact of serendipity has the potential to reverberate beyond the individual, we can also see the importance of serendipity at the micro level – the affective response serendipity evokes and the learning it sparks.

Serendipity can bring simple pleasures and happiness to a person's everyday life (Rubin, Burkell, & Quan-Haase, 2011). Thus, when we view serendipity in terms of its potential to positively influence a person's emotion or affect, we can see how serendipity that occurs within digital environments may have an impact on user engagement, "a quality of user experience with technology" (O'Brien, 2011, p.2). A user who associates a particular news website, for example, with serendipity may be encouraged to return to one of many news websites competing for the user's time and attention.

When we speak of serendipity we are also often implicitly or explicitly referring to learning and understanding. One definition of serendipity reflects this: "As a process of meaning-making, serendipity refers to the phenomenon of spontaneously understanding unexpected things, including time, space, people, and contents" (Liang, 2012, p. 41). Creating meaning, sense making, is spurred by discontinuity (Dervin & Foreman-Wernet, 2003) and surprise. As philosopher Charles Saunders Peirce noted, "Experience is our great teacher; invariably it teaches by means of surprises" (MS 309, 1903 in Nubiola, 2005, p. 128). Surprise is an important human survival mechanism, a brief emotional state caused by an unexpected change in an individual's environment (Olson & Janes, 2002, p.

383), but on an intellectual level the surprise experienced with serendipity has the power to jog our minds, to prod us to think, find meaning, and learn more.

1.3 Support for Serendipity in Digital Environments

While I could find no dictionary or academic definition of digital environment, a search for "digital environment" in the Association for Computing Machinery (ACM) digital library suggests it is used in reference to digital or computer technology in which there is a sense of place. For example, we search *on* Google, we *go to* the ACM digital library, and we explore a shopping website as we might explore its physical counterpart. Therefore, I define digital environments in this thesis very broadly as a computer-based place in which an individual's interactions with people, information, and things are mediated by technology. Because my research is on information-rich, work-related serendipity, the digital environments referred to in this thesis include databases, social media, search engines, websites, and intranets.

Digital environments have traditionally been designed to support effectiveness, efficiency, and satisfaction. As we acknowledge that digital environments have the capacity to do more than match user needs with information, we are gradually moving beyond these criteria, recognizing that more complex interactions take place between users and digital environments; for example, user engagement (O'Brien, 2011) and user hedonic experience (Stelmaszewska, Fields & Blandford, 2004). Rather than conceptualizing information processing as unfolding in a vacuum, information scientists "now take a more holistic view of humans as situated actors within an environment, which strongly influences their thought processes and behaviors" (Marchionini, 2008, p. 169). Cognition is no longer conceptualized as a separate entity from one's body and social, physical, and intellectual environment (Marchionini, 2008). This holistic view extends to digital environments, and the interactions that users have with the information objects, information technologies, and interfaces that comprise these digital environments (Ingwersen & Järvelin, 2005).

Through the connected, information-rich environments they provide, computer devices have the potential to be ideal locations for serendipity. Some consider hyperlinked environments to be fertile ground for serendipity (Guimarães & Carriço, 2010; Merton &

Barber, 2004), providing a diversity of resources to which users may not have otherwise been exposed (Thurman & Schifferes, 2012). Others, however, have expressed concern (e.g., McKeen, 2006; Pariser, 2011; Zuckerman, 2013). While technological developments are maximizing information monitoring, search, and retrieval, these developments have come under attack for a lack of a broader conceptualization of information that recognizes the importance of serendipity – the spark of creativity and innovation that is vital to scientific, economic, environmental, artistic, and social prosperity. The information we encounter while using popular search engines such as Google and Yahoo!, for example, is curated through mechanisms such as personalization and computer-generated relevance judgments to ensure that we are more likely to get the information we want. Social search, on the other hand, "is a variant of information retrieval where a document or website is considered relevant if individuals from the searcher's social network have interacted with it" (Karweg, Hütter, & Böhm, 2011, p. 1825). These mechanisms create a *filter bubble* (Pariser, 2011) or a level of homophily (Zuckerman, 2013) that threatens to limit the sort of information we encounter and consume. However, while speculation about what characteristics and features of digital environments facilitate and inhibit serendipity is common, relatively little research has been undertaken to back up the assumptions making it difficult to recommend approaches for the support of serendipity in digital environments.

1.4 Purpose Statement

Digital environments are not neutral. Through their design and an individual's interactions with them, they have the potential to help or hinder serendipity. Understanding serendipity, what influences it from a holistic perspective, will help lay the groundwork for measurement and facilitation of a phenomenon that has positive and sometimes profound implications. It is vital not only to understand what makes one environment potentially more serendipitous than another but also what role the individual plays in serendipity so that we can design digital environments to support serendipity and evaluate how well the digital environments we design facilitate serendipity. This research will ultimately lay the groundwork for the development, enhancement, and measurement of digital environments that strive to complement more targeted information seeking and monitoring with serendipity.

Therefore, the purpose of this three-phase, sequential mixed methods study was to first explore participant examples of work-related serendipity by collecting data from 12 professionals and academics. Then, based on the themes from the prior research and the qualitative data from Phase 1, a set of questionnaires was developed in Phase 2 to measure serendipity as well as the serendipitous digital environment. The serendipitous digital environment scale was assessed for content validity using an expert review (DeVellis, 2003) and the "ANOVA approach" (Hinkin & Tracey, 1999) before incorporating it into a web-based study in Phase 3 of 289 professionals, academics, and students engaged in thesis work. The serendipitous digital environment (SDE) scale was purified and its reliability and construct validity tested. Further, Phase 3 explored relationships between serendipity, types of digital environments, openness to experience (Lee & Ashton, 2004), extraversion (Lee & Ashton), locus of control of behaviour (Craig, Franklin, & Andrews, 1984), creative environment perceptions (Mayfield & Mayfield, 2010), and proposed facets of the serendipitous digital environment using univariate and multivariate statistical techniques.

1.5 Summary and Structure of Thesis

This research was conducted in three successive phases, each one building on the previous phase. The thesis is structured to reflect this flow.

Chapter 2 explores the definition of serendipity and provides a review of prior research on serendipity and related constructs, models of serendipity, and selected variables associated with serendipity drawn from theoretical and empirical work. (Phase 1)
Chapter 3 gives an overview of the research design and the study population selected for this research.
Chapter 4 reports on a study investigating work-related serendipity, how it unfolds, and what may influence it. (Phase 1)
Chapter 5 reports on the development of facets and items for the serendipitous digital environment (SDE) scale and two studies conducted to refine the questionnaire and assess its content validity. Direct measures of serendipity are also developed in this chapter for use in Phase 3. (Phase 2)

Chapter 6 reports on a web-based study conducted to purify the serendipitous digital environment (SDE) scale, assess its reliability and construct validity, and explore the relationships between serendipity, types of digital environments, and characteristics of the environment and the individual. (Phase 3)

Chapter 7 summarizes and discusses the main research findings from the three phases.

Chapter 8 concludes this thesis with a discussion of the contributions of the research, its limitations, and future work.

CHAPTER 2. PRIOR RESEARCH

2.1 Overview

This chapter examines the literature on the constructs explored and tested in this thesis: serendipity, individual differences, and the environment. It was not possible to explore all of the individual differences associated with serendipity, therefore, three were selected for further exploration based on their salience in prior research and my own investigation of work-related serendipity (Chapter 4): namely, openness to experience, extraversion, and locus of control. Openness to experience and extraversion were identified as potentially important personality traits of individuals who tend to have serendipitous experiences. Recognizing that individuals' perceptions of causation differ – some are more likely to believe that life events are controlled more by events out of their control than others – locus of control was also selected for further examination. The prior research relating to three types of environments, both broad and specific, associated with serendipity is also examined, that is, creative, serendipitous, and digital. The variables in this thesis represent key elements of the interactive information seeking and retrieval (IIS&R) framework (Ingwersen & Järvelin, 2005); the final section of this chapter situates this thesis within the IIS&R framework theoretical framework.

2.2 Serendipity

This section first explores the definition of serendipity. Constructs related to serendipity explored in prior research are identified together with models of serendipity developed from empirical research that help to identify serendipity's conceptual space.

2.2.1 Definition of Serendipity

Serendipity emerged from its origins as a little-known 18th century construct to a popular 21st century catchall term to describe all manner of human discovery and experience. The etymology of serendipity can be traced to its inception in 1754 when Horace Walpole, an 18th century Englishman of letters, coined the term in a letter to a friend (Goodman, 1961). He read *The Travels and Adventures of the Three Princes of Serendip* and described the princes as "always making discoveries by accidents and sagacity, of things they were not in quest of" (as quoted in Merton & Barber, 2004, p. 234). This may have been the first definition of serendipity, but certainly not the last; language is alive and

evolving and the sometimes contradictory and contested evolution of serendipity's meaning reflects this (Baumeister, Hawkins, & López-Muñoz, 2010).

While serendipity has been defined in popular and research literature as well as in dictionaries, using terms such as accident, chance, and luck, throughout its history, serendipity has been characterized by two main conceptual threads:

1) Serendipity as personal aptitude; and
2) Serendipity as a phenomenon or event (Merton & Barber, 2004).

Serendipity as a phenomenon or event implies the presence of certain circumstances or conditions external to and uncontrolled by the individual. The suggestion of a "serendipity-prone" person (Merton & Barber, 2004) who has a certain *faculty, ability*, *gift* or *natural gift*, *aptitude,* or *natural talent* for happy accidents suggests the individual drives serendipity. Pasteur's adage "chance favors only the prepared mind" (as quoted in Liestman, 1992, p. 530) is thus commonly associated with serendipity. Internal and external influences on serendipity, however, do not exist as silos in discussions of serendipity. Merton, for example, argued that "the psychological black box of the 'prepared mind' cannot itself explain the complexities of serendipitous discovery" (Merton & Barber, 2004, p. 259) while Seifert, Meyer, Davidson, Patalano, and Yaniv (1995) proposed that what Pasteur meant by his prepared mind statement "is not that random self-generated recombinations of ideas occur most often to people whose minds are prepared, but rather that prepared minds can and do take advantage of fortuitous encounters with relevant *external* objects and events" (p. 85, emphasis added). The combination of internal and external factors responsible for serendipity has been referred to as the *serendipitous sociocognitive microenvironment* (Merton & Barber, 2004).

Some definitions of serendipity do recognize its complexity. Denrell, Fang, and Winter (2003), for example, propose that, within the context of organizations, "the discovery of a valuable strategic opportunity is often a matter of 'serendipity' in the strict sense—not just luck, but effort and luck joined by alertness and flexibility" (p. 978). Fine and Deegan describe serendipity relative to qualitative research as "the interactive outcome of unique and contingent 'mixes' of insight coupled with chance" (Fine & Deegan, 1996, p. 434). The main elements of serendipity have similarly been described as "a mix of

unexpectedness and *insight* [that lead] to a *valuable, unanticipated outcome*" (Makri & Blandford, 2012a, p. 684). McBirnie and Urquhart (2011) note that their "accepted understanding of the phenomenon requires the internal (e.g., the prepared mind) and the external (e.g., outside context and events) to come together in the right way, with neither on its own considered enough for the classification of an experience as serendipity" (np). Each of these definitions and extrapolations extend the more basic notion of serendipity as an aptitude or a happy accident, embedding within them how and why serendipity unfolds.

Beyond the duel between internal and external causation in definitions of serendipity, the other main point of contention revolves around the notion of intent. Walpole originally referred to the three Princes of Serendip as "making discoveries by accidents and sagacity, *of things they were not in quest of*" (as quoted in Merton & Barber, 2004, p. 234, emphasis added). This suggests that serendipity is defined in part as an incidence of looking for one thing and finding another. This notion is reflected in Merton's (1948) definition of serendipity:

> The serendipity pattern refers to the fairly common experience of observing an *unanticipated, anomalous and strategic datum* which becomes the occasion for developing a new theory or for extending an existing theory. (Merton, 1948, p. 506)

Unanticipated refers to a circumstance in which an unexpected observation is made while testing a hypothesis that is unrelated to the original line of research (Merton, 1948). However, some definitions of serendipity also encompass cases in which individuals find something they were looking for in an unexpected place or manner: "the faculty of finding valuable or interesting things by chance or *where one least expects*" (Universal Dictionary of the English Language, 1932, as quoted in Merton & Barber, 2004, p. 246, emphasis added). Because Walpole was referring to the unexpectedness relating to time rather than place or manner in his original reference to serendipity (Merton & Barber, 2004), this place- or manner-oriented type of serendipity has been referred to as *pseudo serendipity* (Roberts, 1989; van Andel, 1994). However, pseudo serendipity is often folded into the definition of serendipity itself (Rubin, et al., 2011). Pseudo serendipity, for example, is one of the patterns of serendipity identified by van Andel and means "to

discover, invent, create something you were looking for in a surprising way" (van Andel, 1994, p. 639). McBirnie (2008) adopts van Andel's neutral perspective, describing serendipity as "both passive and active, suggesting that serendipity can involve unexpected results, unexpected changes in direction, and/or the finding of something in unexpected environments or from unexpected sources" (p. 604). I also take this more inclusive view of serendipity, recognizing that the meaning of serendipity has evolved since first articulated.

This thesis adopts a holistic definition of serendipity that makes room for serendipity as an experience in which the existence of intentionality does not rule out serendipity:

> *Serendipity is an unexpected experience prompted by an individual's valuable interaction with ideas, information, objects, or phenomena.*

This definition of serendipity shares many of the features of the definitions discussed in this section. Each of these definitions emphasizes a different aspect of the phenomenon and my own highlights three elements that I have found most important in my research: the *unexpected* and *positive* aspects of the phenomenon as well as the *interaction* that takes place between the individual and the environment that drives the experience.

The word *unexpected* is used in the above definition – all definitions of serendipity agree that there is an unexpected component to the experience, whether it is the purist's definition of serendipity or inclusive of pseudo serendipity. There is also agreement among definitions, whether implicit or explicit, that serendipity has a positive rather than a negative connotation, which is why the definition includes the word *valuable* – the experience is in some way useful or beneficial. But it is not just a valuable experience; serendipity describes a valuable *interaction* in which the individual engages with *ideas, information, objects, or phenomena*. The prepared mind, sagacity, and insight evident in many definitions of serendipity are implicit in this definition – the interaction will not be valuable unless the individual's mind is engaged. Furthermore, the definition purposefully indicates an interaction without indicating what influences that interaction – that is left to the research to discover. While this is my definition, in part developed through the integration of previous definitions, research, as well as interviews with professionals and academics on serendipity (Chapter 4), various interpretations of serendipity as well as

alternative terms that relate to serendipity research have been developed in various disciplines. These related constructs are explored in the following section, as they are part of what we have come to understand as serendipity.

2.2.2 Related Constructs

Serendipity has been related to other constructs such as synchronicity, coincidence, and chance and researchers have added their own variations on these more commonly used words. Rather than being distinct from these other constructs, serendipity is viewed in this thesis as a broad concept in which many constructs overlap in meaning or are best situated under the broader umbrella of serendipity. The term *serendipity* is often used in the literature of both information seeking and behaviour (e.g., Björneborn, 2008; Foster & Ford, 2003) and information retrieval (e.g., André, Teevan, & Dumais, 2009; Campos & Figueiredo, 2002). However, researchers from multiple disciplines continue to develop and use specific terminology to attempt to capture the nuances of serendipity relating specifically to, for example, information behaviour and vocational and career development and behaviour. A list of serendipity-related constructs together with their definitions is provided in Appendix 1.

While information seeking and behaviour professionals and researchers still commonly refer to serendipity-related concepts as *serendipity*, new terminology was designed to enable more precision in meaning than *serendipity* could provide (Erdelez, 2004). The differences in many of the definitions of serendipity-related constructs are subtle with five main conceptual threads appearing in the majority of the constructs.

1) *Mode of intent preceding encounter* – the activity the individual was engaged in leading up to the encounter was either *purposive* (e.g., information seeking with a specific topic in mind), *non-purposive* (e.g., browsing without a goal), or both;
2) *Location of encounter* – where the encounter occurred (e.g., web);
3) *Encounter itself* – what was encountered, discovered, found, or observed (e.g., information, source);
4) *Encounter in relation to intent – incidental* if the mode of intent was non-purposive; *related* or *unrelated* to what was sought if the mode of intent was purposive; and

5) *Nature of encounter* (e.g., useful, interesting, valuable).

To see patterns in the conceptualization of the constructs, the two elements relating to intent (i.e., *mode of intent preceding encounter* and *encounter in relation to intent*) are illustrated in Table 1.

Table 1 Mode of intent preceding encounter and encounter in relation to intent in selected serendipity-related constructs

MODE OF INTENT PRECEDING ENCOUNTER (Purposive / Non-purposive / Both)	ENCOUNTER IN RELATION TO INTENT		
	Incidental	Unrelated	Related
Serendipitous information encounters (Foster & Ford, 2003)	Both	Purposive	Purposive
Opportunistic discovery of information (ODI) (Erdelez & Makri, 2011)	Both	Purposive	
Accidental information discovery (Heinström, 2006; Williamson, 1998)	Both	Purposive	
Incidental information acquisition (IIA) (Heinström, 2006; Williamson, 1998)	Both	Purposive	
Everyday chance encounters (Rubin, et al., 2011)	Both	Purposive	
Incidental exposure to online news (Yadamsuren & Erdelez, 2010)	Both	Purposive	
Opportunistic acquisition of information (OAI) (Erdelez, 2004)	Both	Purposive	
Chance encounter (Toms, 2000)	Non-purposive		
Chance events (Bright, Pryor & Harpham)	Non-purposive		
Incidental news exposure on the web (Tewksbury, et al., 2001)	Non-purposive		
Non-directed monitoring (McKenzie, 2003)	Non-purposive		
Serendipitous information retrieval (Toms, 2000)	Non-purposive		
Incidental news exposure online (Lee, 2009)		Purposive	
information encountering (IE) (Erdelez, 2005)		Purposive	
Serendipity in information seeking (SIS) (McBirnie, 2008)		Purposive	

Three main clusters of meaning were identified and share similar elements that suggest few differences among a plethora of terms. Most of the serendipity-related constructs in Table 1 are encounter-centric, focusing on the information search, discovery, and

acquisition aspects of serendipity rather than the subsequent use or the outcome of the encounter or the individual differences that may have influenced it. Serendipitous information encounter (Foster & Ford, 2003) is the "stand-alone" and represents the broadest serendipity-related construct; *serendipitous information encounters* encompass a wide range of manners in which information was found and is inclusive of both sought and unsought information. The *opportunistic discovery of information* (Erdelez & Makri, 2011) cluster represents those constructs that encompass both incidental and unrelated encounters during purposeful or non-purposive information behaviour. The *chance encounter* (Toms, 2000) cluster and the *information encountering* clusters are slightly more specific. The *chance encounter* cluster refers to incidental encounters during non-purposive information behaviour which contrasts with the *information encountering* (Erdelez, 2005) cluster that refers to unrelated encounters during purposive information behaviour. The following review of prior research is inclusive of these conceptualizations of serendipity. When discussed broadly, the term *serendipity* is used, though specific terminology is retained where possible.

2.2.3 Models of Serendipity

Erdelez's (2004) model of an information encountering (IE) episode details part of serendipity – the *beginning* of a potentially serendipitous experience. As previously mentioned, this aspect of serendipity dominates the literature. Based on two studies involving 132 responses to survey questionnaires and in-depth interviews with twelve of these respondents, Erdelez illustrated how an IE episode relating to a background problem is embedded within an information seeking activity relating to a foreground problem. The IE episode consists of *noticing, stopping, examining, capturing*, and *returning*. Four recent empirical models of serendipity in Information Science have emerged to describe serendipity in full and were derived from research with a common purpose: to gain a greater understanding of serendipity in everyday life (Rubin et el., 2011) or research (Makri & Blandford, 2012a; McCay-Peet & Toms, 2010; Sun, Sharples, & Makri, 2011). While two emphasize how people come to perceive their experience as serendipitous (Makri & Blandford, 2012a; Rubin et al., 2011), the other two emphasize the context of serendipity (Sun et al., 2011) or how it is facilitated (McCay-Peet & Toms, 2010). The models are complementary, offering different levels of

granularity and nuanced perspectives on serendipity that is evident in Table 2. McCay-Peet and Toms' (2010) model is adapted from Cunha's (2005) conceptual model of serendipity in organizational management and thus Cunha's model is included among those outlined in Table 2.

The main elements included in one or more of the five models are organized by theme:

1) Precipitating conditions or context;
2) Noticing;
3) Connection;
4) Post-connection;
5) Unexpected, chance, or accidental aspect;
6) Positive aspect or outcome; and
7) Reframing of or reflection on experience.

The row order is loosely based on the order of occurrence, as there is a linear, though in some cases iterative, process discernable in the models.

Table 2 Comparisons of the main elements of serendipity in five serendipity models

Rubin, Burkell, & Quan-Haase, 2011	**Makri & Blandford, 2012a**	**Cunha, 2005**	**McCay-Peet & Toms, 2010, adapted from Cunha, 2005**	**Sun, Sharples, & Makri, 2011**
Precipitating conditions or context				
		Search for Problem A; Precipitating conditions: relationships, temporal happenstance, active learning	Search for solution to task A; Precipitating conditions: relationships, temporal happenstance, active learning	Context: social and physical environment, time, pressure, focus of activity, attentional resources available
Noticing				
Facet B: Act of noticing: observation/ attention (relating to the find)			Trigger	Noticing, examining
Connection				
Facet A: Prepared mind: prior concern + previous experience (relating to the find)	Make new connection; Insight	Bisociation	Bisociation	Making connections
Post-connection				
	Project potential value of outcome; Exploit connection			

(Table continued on next page)

Rubin, Burkell, & Quan-Haase, 2011	Makri & Blandford, 2012a	Cunha, 2005	McCay-Peet & Toms, 2010, adapted from Cunha, 2005	Sun, Sharples, & Makri, 2011
Unexpected, chance, or accidental aspect				
Facet C: Chance: accidental nature/ perceived lack of control (relating to the find); Surprise	Unanticipated outcome, unexpectedness of circumstances	Unexpected solution; temporal happenstance	Unexpected solution; temporal happenstance	Unexpected connections, unexpected finding of information
Positive aspect or outcome				
Facet D: Fortuitous outcome: perceived gain/happy ending (relating to the find)	Valuable outcome	Solution for problem B	Solution to Task A or B	Positive impact (short term or long term)
Reframing of or reflection on experience				
Serendipity: re-framing events/ story retold/ unsought finding	Reflect on: value of outcome and unexpectedness of circumstances and role of insight; Consider as serendipity			

In the first two columns of Table 2, we see that Makri and Blandford's (2012a) and Rubin et al.'s (2011) models highlight the perceptions and internal thought processes of serendipity and how individuals come to perceive an experience as serendipitous, using words such as *perceived, reflect on,* and *reframe*. Developed through an analysis of fifty-six accounts of chance encounters in blog entries, the *conceptual model of serendipity facets in everyday chance encounters* (Rubin et al., 2011) identifies four main facets of serendipity relating to *the find*: *prepared mind*, *act of noticing*, *chance*, and *fortuitous outcome.* The model illustrates how the individual reframes an experience as a story of serendipity in retrospect when the fortuitous outcome is perceived. Similarly, a key component of the *empirically grounded process model of serendipity* (Makri &

Blandford, 2012a) is that a person considers an experience serendipitous at the end of an iterative, self-reflecting process. Derived from a study of twenty-eight interdisciplinary researchers' serendipitous experiences using the critical incident technique, the model (Makri & Blandford, 2012a) illustrates that a person first makes a *new connection* between some *thing* and a *need*, *projects the potential value of an outcome* of the connection made, and *exploits the connection* to gain a *valuable, unanticipated outcome*. A person may *consider the experience serendipity* after reflecting on the *outcome*, the *insight* involved, and its *unexpectedness*.

The other three serendipity models (Cunha, 2005; McCay-Peet & Toms, 2010; Sun et al., 2011), summarized in the last three columns of Table 2, take a less inward-turning approach and focus more on what may influence the process from the outset. In their preliminary model, McCay-Peet and Toms (2010) adopted a conceptual model of the serendipity process (Cunha, 2005) from organizational management as a framework for the analysis of previously collected interviews with ten historians on their information seeking behaviours (Duff & Johnson, 2002). The process of serendipity in knowledge work is described as such: 1) while *searching for a solution to task A* and 2) immersed in *precipitating conditions* (relationships, temporal happenstance, active learning), 3) a person perceives a *trigger* or external stimulus (e.g., images, text), that 4) sparks a *bisociation* or clash of mental models between previously unconnected information or ideas, leading to 5) an *unexpected solution to task A or B* (a problem that was not initially intended to be solved) (McCay-Peet & Toms, 2010). *Precipitating conditions* (Cunha, 2005) is the most salient element of this model as it illustrates the hypothesis that there is something that may be done to facilitate serendipity. McCay-Peet and Toms' and Cunha's models primarily differ in that Cunha's does not encompass pseudo serendipity (i.e., solution to problem B only, not A or B) nor does Cunha's model include the *trigger* that sparks serendipity.

Context, similar to precipitating conditions, was incorporated into a model of serendipity derived from a mobile diary study and interviews of eleven PhD students to examine what impacts serendipity (Sun et al., 2011). Sun et al. use Schmidt's (2000) conceptualization of context that includes human factors (information about the user, their social

environment, and tasks), the physical environment (location, infrastructure, and physical conditions), and time that is integral to both human factors and the environment. Context impacts how ready the individual is to have a serendipitous experience based on the pressure felt by the individual, the degree of focus the individual has on a current activity, and the availability of the individual's attentional resources (Sun et al., 2011). Furthermore, the environments in which serendipity occurs include: 1) working environments that are resource-rich (e.g., an office); 2) places that are designed to provide information (e.g., libraries, conferences); and 3) constantly changing environments in which there is new information (Sun et al., 2011).

Although the five serendipity models focus on different parts of the process, they generally converge on the main elements of the process with similar terminology and meaning. Differences in the models may be attributed to methodology; for example, the interviews (Makri & Blandford, 2012) versus analysis of blog entries (Rubin et al., 2011) may have led researchers to focus more on some elements than others. More research is needed to confirm and augment these models; in particular, an understanding of work-related serendipity that extends beyond research and into other areas of human endeavour is needed. As well, missing from these models is a more comprehensive explanation of what may influence serendipity within the structure of the process of serendipity. Precipitating conditions and contextual factors that may facilitate or hinder the process are proposed, but they primarily address the front end of a serendipitous experience, the *information encounter* (Erdelez, 2004), rather than the whole process. Moreover, if we are to develop approaches and technologies to support serendipity, we need to operationalize and test the variables that are hypothesized to influence serendipity.

2.3 Individual Differences

One of the main assumptions embedded in definitions and models of serendipity as well as this research, is that individual differences – characteristics, traits or abilities that vary between individuals – help explain why serendipity occurs more frequently for some than others. Research points to several factors that may influence serendipity including *openness to experience* and *extraversion* as well as what may influence perceptions of chance events – *locus of control*.

2.3.1 Openness to Experience

In psychology, openness to experience has been identified as one of the Big Five personality traits together with conscientiousness, extraversion, agreeableness, and neuroticism (McCrae & Oliver, 1992). Lexical studies of personality structure commonly describe those open to experience as "Intellectual, creative, unconventional, innovative, ironic versus shallow, unimaginative, conventional" (Ashton & Lee, 2007, p. 154). Lee and Ashton (2004) identified four main facets of openness to experience: aesthetic appreciation, inquisitiveness, creativity, and unconventionality. Those who score high on the openness to experience domain of the HEXACO Personality Inventory tend to be sensitive to beauty in all its forms, actively seek out information and experiences, have a wide range of interests, like to experiment, and are receptive to nonconformist ideas and people (Lee & Ashton, 2004).

Those with high levels of openness to experience may gain materially and socially from their discoveries, though this takes both time and energy (Ashton & Lee, 2007) and the cost-gain trade off is reflected in research findings related to social media use. In surveys of 237 undergraduate students in which NEO 5-factor personality inventory was administered, Amichai-Hamburger and Vinitzky (2010) found that those more open to experience were more willing to use Facebook and tended to use more of its features. Dantonio, Makri, and Blandford (2012) found in their interviews with 15 postgraduates about their experience of encountering academic social media content serendipitously that spending both time and energy creating, sharing, and exploring content and making an effort to engage in conversations on social media sites led to more opportunity for serendipity.

Inquisitiveness, a facet of openness to experience (Lee & Ashton, 2004) shares a conceptual relationship to information seeking, but has also been associated with information encountering. Pálsdóttir (2010) examined both purposive information seeking behaviour and information encountering relating to health and lifestyle information behaviour. Based on the quantitative analysis of two postal surveys, each with 1,000 respondents ages 18 to 80, Pálsdóttir found that respondents who tended to actively seek information were also those who tended to encounter information they

were not looking for. This finding is similar to Lee's (2009) from his PhD research on incidental news exposure. From a content analysis of newspapers and television newscasts, a survey of 998 adults, and a lab experiment with 194 undergraduate students, Lee found that the more time individuals spent on the internet finding information – using a search engine and getting entertainment and sports information – the more they were incidentally exposed to public affairs information (Lee). Together, these findings (Lee; Pálsdóttir) suggest that an active interest or *inquisitiveness* increases the likelihood of bumping into items of interest when not expressly searching for them. This reflects findings from interviews with 12 university employees and students who frequently encountered information (Erdelez, 1995). Participants reported that they had the qualities of "openness, passion of multiple interests, interest in collection of information, and joy in exploration" (p. 88).

An exploration of the relationship between creativity, a dimension of openness to experience (Lee & Ashton, 2004), and serendipity is another gap in serendipity research. It has been posited that *creative imagination* is a necessary component of serendipity in science – scientists must not only draw upon their knowledge and experience (prepared mind) but also their creativity to provide an explanation for unexpected observations (Barber & Fox, 1958). Merton (1948) noted serendipity's relation to Peirce's concept of abduction – the construction of creative explanations for observations or the notice of a "surprising fact" that leads to the development of a hypothesis. The abductive experience has been described as like being "jerked from our perceptual and conceptual slumber with a surprise" (Merrell, 2005, p. 93) and thus has also been related to divergence. From a sample of 268 men, McCrae (1987) found a relationship between self-report, peer, and spouse ratings of openness to experience and creativity and divergent thinking. Divergence is a common theme in the serendipity research (Björneborn, 2008; Campos & Figueiredo, 2002; Heinström, 2006, p. 587). Divergent search styles, for example, involving explorative *broad scanning*, "a search style where a topic is spontaneously explored through a wide use of sources" (Heinström, 2006, p. 587) are related to incidental information acquisition (Heinström, 2006).

Despite the theoretical connections between openness to experience and serendipity, the relationship may be more complex than expected. Hirschi's (2010) research on personality and chance factors in career development, based on survey questionnaires of 229 grade eleven students and 245 grades eight and nine students, suggests this complexity. Using a German-language version of the NEO Personality Inventory, Hirschi found that while openness to experience was positively related to the perception of the importance of chance events to career development in the younger student study, it was negatively related in the older student study. Hirschi speculated that the older cohort had more time to downplay the influence of chance events on their career transitions than the younger students. In other research relating to students' incidental information acquisition (IIA) (Heinström, 2006), two studies (n=305 masters' students; n=27 library and information science students) in which the NEO Personality Inventory was administered found no significant relationship found between openness to experience and a tendency to experience IIA. Therefore, while there is theoretical support for the hypothesis that openness to experience has a significant and positive relationship with serendipity, more empirical research is required to support these findings and explore their complexities. McCrae (1987), for example, was careful to point out that while research indicates a relationship between openness to experience and divergent thinking, practice over time or incentives may lead those with relatively low openness scores to do equally well on divergent thinking tasks as open individuals. This finding raises an important point – that of personal control which will be further explored in the forthcoming section on locus of control.

2.3.2 Extraversion

Extraversion is "the act, state, or habit of being predominantly concerned with and obtaining gratification from what is outside the self" (Extroversion, n.d.) and, like openness to experience, it is one of the core dimensions in personality models. Across multiple lexical studies, extraversion is associated with being "outgoing, lively, extraverted, sociable, talkative, cheerful, active versus shy, passive, withdrawn, introverted, quiet, reserved" (Ashton & Lee, 2007, p. 154). Extraversion is associated with the interpersonal behaviours that characterize expressiveness, social boldness, sociability, and liveliness (Lee & Ashton, 2004). Those who score high on the

extraversion domain of the HEXACO Personality Inventory, tend to be more excitable, dramatic, talkative, enjoy social interactions, and are enthusiastic and optimistic. Low scorers tend to be less confident in social situations, solitary in their behaviour, and reserved in their interactions with others (Lee & Ashton). Those with high levels of extraversion may benefit from having more social connectivity, though this, like openness to experience, comes at the cost of time and energy and potential social risks (Ashton & Lee).

With respect to technology, relationships have been found between extraversion and the use of social media (Amichai-Hamburger & Vinitzky, 2010; Correa, Hinsley, & de Zúñiga, 2010; Ross, Orr, Sisic, Arseneault, Simmering, & Orr, 2009). For example, in Correa et al.'s study of 1482 American adults that examined the relationship between the use of social media (instant messaging and social networking sites), personality, and demographics, both men and women who were extraverted tended to report using social media more frequently. Moreover, interviews with graduate students indicates that use of social media facilitates serendipity (Dantonio, Makri, & Blandford, 2012). Researchers have extrapolated from findings such as these to suggest ways to increase the likelihood of serendipity. Based on a survey 651 university students that indicated exposure to a variety of chance events significantly and positively impacted individuals' careers, Bright, Pryor, Wilkenfeld, and Earl (2005) urged career counselors to encourage students to engage in a variety of activities, such as volunteer work, participation in clubs, and increased interaction with people and groups in general. In other words, extravert-like interpersonal behaviours should be encouraged so that students can reap the benefits of positive chance events.

Despite the associations made between extraversion and serendipity, very little direct investigation of the relationship has been undertaken. One exception was research on incidental information acquisition (IIA) and personality using the NEO Five Factor Inventory (Heinström, 2006). In two survey studies (N=305 masters' students; N=27 ILS students) reported by Heinström, the extraversion personality factor was significantly related to students' propensity to experience incidental information acquisition – "acquiring (useful or interesting) information while not consciously looking for it" (p.

580). However, as indicated previously, IIA represents only the initial part of serendipity. Whether or not extraversion is related to a more holistic conceptualization of serendipity is as yet unknown.

While there is a need to further explore the relationship between the behaviours associated with extraversion and serendipity, prior research also suggests that this relationship should not be overstated. McBirnie and Urquhart's (2011) findings from an analysis of 50 narratives randomly drawn from the Citation Classics Database indicate that while social interaction facilitates serendipity, "social interaction is not a necessary condition of serendipity" (np). Four common interaction *motifs*, recurring themes or patterns, of the serendipitous experiences of scientists were identified relating to interactions between *ego* (i.e., the person experiencing serendipity), *person* (e.g., a colleague), *object*, and *information*: 1. *exchange*, 2. *solo*, 3. *collaboration*, and 4. *chain*. While *exchange*, was the most common pattern of interaction and involved interaction with other people, *solo* and *chain* motifs rarely involved interactions with other people and rather relied solely on the person's interaction with information and objects (McBirnie & Urquhart, 2001). Therefore, while a handful of studies point to a relationship between extraversion and serendipity, more research is needed to further explore the complex relationship between serendipity, extraversion, and interpersonal behaviours both with and without computer mediation.

2.3.3 Locus of Control

Locus of control has been explored in a range of psychology research including mental health, organizations, and education, and refers to a person's sense of control that exists on a continuum between internal and external. It is defined as "the degree to which an individual sees himself in control of his life and the events that influence it" (Locus of control, n.d.). Some individuals are more likely to attribute happenings in their lives to their own actions, suggesting an *internal* locus of control. Other individuals are more likely to attribute happenings to events outside of their power, implying an *external* locus of control (Rotter, 1966). Locus of control scales such as the Locus of Control of Behaviour (LCB) scale (Craig et al., 1984) have been developed to measure perceived control of personal behaviour and include perceptions

of the role of chance, luck, and outside support versus an individual's personal control over their problems, situations, and life in general.

The concept of locus of control extends to interactions with computer technology in which individuals' perceptions of control, a dimension of cognitive absorption or deep involvement with software, vary (Agarwal & Karahanna, 2000). Design of computing technology stresses the importance of users of being in control of interactions, thus situating internal locus of control as a design principle. One of the "Eight Golden Rules" of interface design encourages *support for internal locus of control* (Shneiderman & Plaisant, 2009, p. 71) and urges designers to ensure users have control of their experience in interactive systems and thus design systems to be familiar and unsurprising.

While support for internal locus of control in computer technologies is embedded in best practices, it also has a presence in education where teachers are urged to teach students how to take control of their own information seeking and learning and, somewhat paradoxically, serendipity (McBirnie, 2008). For example, educators are encouraged to nurture creative thinking (Sawaizumi, Katai, Kawakami, & Shiose, 2007), teach serendipity as a method of scientific discovery (Lenox, 1985), encourage students to develop a more serendipitous or non-linear style of resource exploration and research (Delgadillo & Lynch, 1999; George, 2005; Nutefall & Ryder, 2010), to generally embed serendipity into the learning process (Crowther, Loh, & Sanders, 2010), and, as previously mentioned, encourage extravert-like behaviour (Bright, Pryor, Wilkenfeld, & Earl, 2005). Nutefall and Ryder, for example, through their interviews with seven faculty members and instruction librarians concluded that serendipity involves "the development of a certain habit of mind or methodology that allows the accidental discovery of information to happen" (Nutefall & Ryder, 2010, p. 231).

Encouraging extraversion, openness to experience, creativity, and curiosity is seen as a way for individuals to facilitate their own serendipity. In this way, individuals are asked to take a phenomenon primarily defined by its externality – its qualities of unexpectedness, randomness, chance, and accident outside an individual's immediate

locus of control – and implement personal strategies for obtaining its benefits. However, no empirical evidence exists that any particular strategy leads to serendipity. For example, while Sawaizumi et al.'s study of 14 university students use of "serendipity cards", a paper-based tool designed to help introduce students to the concept of serendipity, led them to conclude that the cards helped students think more deeply about the concepts they encountered, their use failed to facilitate serendipity.

But individuals do report personal strategies for serendipity that at least suggests some level of efficacy derived from the application of personal methods or strategies. Artists and designers, for example, seek out environments that allow them to explore image collections and other sources of inspiration and information that enable serendipitous finds (Medaille, 2010) or information encountering (Makri & Warwick, 2010). *Super-encounterers*, those that experience information encountering frequently and are self-aware of that process, believe they have a hand in increasing their chances of information encountering through how they behave and the situations they create for themselves (Erdelez, 1995). Ensuring other people are aware of one's interests, for example, was identified as a useful approach to information encountering (Erdelez,1995). From interviews with 194 adult readers, Ross (1999) found that avid readers often create their own opportunity for serendipity through the way in which they select their books; these readers attempt to create a balance between reading books that are sure to please them and books that might surprise them and are outside their normal subject area, genre, or favourite group of authors through random selection. In this sense, planning is involved, but something is still left to chance.

But how pervasive is this perception of personal control over serendipity? From a sample of 237 older adults, Betsworth and Hansen (1996) found that the majority of respondents, nearly two-thirds, felt that their careers were in some way influenced by serendipitous events including, for example, *unexpected exposure to interest area* and *right time/right place*. A significant proportion of the women college graduates perceive that *unexpected personal events* had a significant impact of their career paths (Scott & Hatalla, 1990), which has been confirmed in more recent studies (Bright, Pryor, Wilkenfeld et al., 2005). Since serendipity and chance are often associated with conditions outside one's control,

are some individuals more likely to attribute serendipity to environmental factors than their own actions? Depending on how methods and strategies for information encountering are implemented, for example, the personal control exerted by individuals may impede their perceptions of serendipity. Rubin et al. (2011) underline the importance of chance in the perception of an experience as serendipitous; the *find* (an idea, item, or person) must be by *chance,* unplanned or accidental, representing a lack of control in some respect on the part of the finder.

But an individual's propensity to *perceive* experiences as *chance events* is not black and white and instead may be attributable to individuals' *locus of control* (Bright, Pryor & Harpham, 2005; Hirschi, 2010). In other words, while one person may view the outcomes drawn from strategies of random book selection as serendipitous or a great job offer as a chance event, others may instead focus on how they themselves had a hand in the find or worked hard for the oppportunity. Using Craig et al.'s (1984) scale measuring locus of control of behaviour (LCB), Bright, Pryor & Harpham (2005) found that individuals with an internal locus of control perceive their career paths are less influenced by chance events than those with an external locus of control. Using a different measure of locus of control – Krampen's Inventory for the Measurement of Self-Efficacy and Externality – Hirschi (2010) similarly found students with more external control beliefs were more likely to indicate the influence of chance events on their career choices and development. However, more research is necessary as a study by Bright, Pryor, Chan and Rijanto (2009) of university students and working adults indicated no significant relationship between the influence of positive chance events and LCB (Craig et al., 1984).

The theme of control is also present in the serendipity literature in how individuals react to chance encounters and exploit unexpected findings (Barber & Fox, 1958; Campanario, 1996; Foster & Ford, 2003). While the 45 interdisciplinary scholars interviewed by Foster and Ford used terms such as *randomness, chance, accidents* and phrases such as *just happened to* to describe events that lead to serendipity, they also recognized their own role in serendipity (Foster & Ford, 2003). These scholars noted that one must have an open attitude and take a broader view, and "consciously to be open and receptive to chance information encounters" (p. 335). Similarly, scientists

have expressed the need to be psychologically prepared for and pay attention to the unexpected and be willing to be flexible to diverge from a planned line of research in order to follow up on unexpected observations (Campanario, 1996). This personal level of control over serendipity is underlined in Barber and Fox's (1958) case study of two scientists in which both observed the same puzzling phenomenon, but only one followed up on it and one thus experienced "serendipity gained" and the other "serendipity lost." It seems that individuals sometimes *filter out* serendipity, refraining from acting upon potentially serendipitous experiences if they feel under pressure, do not want to be diverted, or are otherwise focused on the task at hand (Dantonio, 2010; Erdelez, 2004; McBirnie, 2008; Miwa, Egusa, Saito, Takaku, Terai, & Kando, 2011; Toms & McCay-Peet, 2009).

McBirnie (2008) found through interviews with two jazz improvisers and eight academics on their information seeking behaviours that while participants reported that they could not "help but notice the unexpected," (p. 608) some were more willing than others to diverge from their original information seeking goals. In an attempt to induce an episode of information encountering (IE) in a controlled, web-like setting, Erdelez (2004) had participants (students with a shared class assignment) evaluate the relevancy of search results in which she embedded a hyperlink that would have aided them in their assignment. Nine out the ten participants noticed the IE trigger, but none acted on it. While the study attempted to induce a complete information encountering experience (noticing, stopping, examining, capturing, and returning), Erdelez posited that, despite the relevance of the embedded result to the background problem, the students were too motivated by the cover task and subsequently suppressed their urge to move beyond the noticing stage of the information encounter. This conclusion is supported in other research in which students with defined and focused tasks were less likely to diverge from their topics when they experience information encountering than students with ill-defined tasks or uncertain goals (Miwa, et al., 2011). This suggests that students may be more open to information encounters in the early stages of their tasks when *novel* information that piques their curiosity may help them to define their topic or their goal (Miwa, et al., 2011). Sun et al. (2011) also noted the temporal-control factor of serendipity, observing that serendipity was perceived to happen, at

least in one case, when a Ph.D. student was in the early stages of a work project and more open to new ideas.

The complexity of studying serendipity and particularly how to support serendipity is in large part centred on the issue of control. Individuals develop methods and strategies to attempt to control when and how often they experience information encountering and they also protect themselves from diversion by filtering out potentially serendipitous observations when they do not have the time to deal with them. In other words, when individuals have an information encounter, they decide whether or not to react based on time and inclination. At the same time, the personal control an individual exerts on the process of serendipity impacts whether or not the information encounter is perceived as serendipitous. And this situation is further complicated by the subjectivity of it all; whether an individual has an internal or external locus of control may influence whether or not an experience is perceived as chance or serendipity. While research on career development has explored the relationship between chance events and locus of control, no known studies have explored the influence of locus of control on the perception of more information-centric experiences such as information encountering and the type of work-related serendipity that is the focus of this thesis.

2.4 Environments

Another thread of this research, as well as definitions and models of serendipity, is that things external to an individual influence serendipity: environment, context, or situational factors. This thesis focuses in particular on the more stable characteristics of the individual's environment rather than situational factors such as task or the time pressures that may be associated with a given task. This focus is reflected in the following sections that explore the prior research on the creative and serendipitous environment – characteristics relating to individuals' social environments such as relationships with colleagues as well as features or qualities of the physical and digital environments in which they interact that influence serendipity.

2.4.1 Creative Environments

As noted earlier, creativity is one of the facets of openness to experience (Lee & Ashton, 2004). But creativity has also been linked to environmental conditions (Mayfield &

Mayfield, 2008). For example, one broad definition of creativity includes the environment: creativity is "a combination of interacting individual and environmental resources leading to the production of valuable solutions" (Mouchiroud & Bernoussi, 2008). Research has examined the effect of the environment on creativity. With the right environmental conditions, an individual's creative output may be enhanced leading to the creation of new products and ideas (Oldham & Cummings, 1996) or creative solutions to social problems (Mouchiroud & Bernoussi). The nurturing of a creative work environment is also a means to retain employees (Mayfield & Mayfield, 2008).

The role of the environment in creativity has primarily been examined in relation to individuals' social and work environment. Oldham and Cummings (1996), for example, examined job complexity and supervisory style as determinants of intrinsic motivation and creative performance at work in a study of 171 employees in a variety of positions from two manufacturing facilities. Findings indicated that workers with higher creativity scores, more complex jobs, and non-controlling managers were good predictors of creative output. In a study of the social creativity of 70 pre-adolescent boys and girls, Mouchiroud and Bernoussi (2008), similarly found that environment matters. The children's creative problem solving abilities were related to teacher, peer, and parent assessments of the childrens' social abilities, popularity, parenting style, and participation in extra-curricular activities.

Creative environment perceptions not only impact creative output, but also how workers behave. Through a survey of 125 graduate and undergraduate students with work experience, Mayfield and Mayfield (2008) found a strong relationship between employee creative environment perceptions and worker intention to leave their job. Findings suggested intent to turnover could be mitigated through rewards for creative solutions in the work place (creativity support), removal of creativity blocks such as impossible deadlines, and more flexibility in job responsibilities (work characteristics). Mayfield and Mayfield (2010) have since developed and tested a questionnaire to measure creative work environment perceptions through a survey of 221 graduate and undergraduate students. The creative environment perception (CEP) scale was developed to explore the "garden variety creativity" with respect to workers, emphasizing the influence of a work

place environment rather than personality traits on creativity and specifically the latent interrelated variables of creativity support, work characteristics, and creativity blocks. Developments of measures of creative environments are important if we are to understand interactions between people and their environments. Oldham and Cummings (1996), for example, noted that while placing employees with high levels of creativity in complex jobs and under the supervision of a non-controlling manager may enhance these employees' creativity, this approach might have no effect or potentially an adverse effect on employees with low levels of creativity who may be annoyed or stressed by these conditions and thus lower their creative performance.

Creativity support tools have been developed to aid or augment creativity. An agent-based creativity support tool, combinFormation (Kerne, Koh, Smith, Webb, & Dworaczyk, 2008), for example, was created to allow students to combine images and chunks of text to create a playful environment that encourages exploration. The system allows for searching, browsing, and collection of content with which a user can interactively engage and the juxtapositions of text and images and the playfulness of the environment is designed to facilitate creative associations. In a field study of 182 undergraduate students in a course on the design process, students using combinFormation performed better on their assignments than those who used Google to search and Word to assemble results. More research, however, is required to measure what role combinFormation may play in the creative process (Kerne et al.). Furthermore, while the creators of combinFormation proposed that the tool creates "opportunities for serendipity" (Kerne, et al., p. 531), this, too, requires further testing.

There are many areas of convergence between creativity and serendipity research. Both creativity and serendipity research suggests that support for these phenomena is possible through education, practice, and tools. Moreover, the theme of flexibility in the creative environment research (e.g., Mayfield & Mayfield, 2008; Mouchiroud & Bernoussi, 2008) finds a conceptual parallel with divergence and flexibility in the serendipity research (e.g., Björneborn, 2008; Campos & Figueiredo, 2002; Heinström, 2006). Time pressures as blocks to creativity (Mayfield & Mayfield, 2008) have also been noted as hindrances to serendipity (e.g., McBirnie, 2008; Sun et al., 2011). Despite the potential for a creative

work environment to support not just creativity but also serendipity, no research to date has explored the relationship between the creative work environment and serendipity.

2.4.2 Serendipitous Environments

Very little research has explicitly examined what characteristics of the environment are related to serendipity. The research that does exist suggests that not all environments are created equal and some appear more likely to support serendipity than others. Björneborn (2008) examined the characteristics of the physical library space that lead to divergent behaviour and reasoned that these features in turn support serendipity. Over a period of several months, the information behaviours that patrons of two libraries used to find resources in public libraries were observed. A portion (n=118) of those patrons were invited to engage in a short interview to collect self-report data on their information behaviour and 11 further participated in think-aloud sessions in which the patrons walked through the library with a researcher and reflected upon their information behaviours and what triggered their attention in the physical library space. Björneborn identified ten "serendipity dimensions" of the physical library:

1) Unimpeded and direct access to library resources;
2) Diversity of resources, activities, and physical spaces;
3) Curiosity-invoking displays of resources;
4) Striking contrasts between the physical library spaces (i.e., quiet zones versus display zones);
5) Pointers such as signs that remind users of interests;
6) Imperfections in the library interfaces (e.g., misshelved resources);
7) Cross contacts that reach across multiple topics, activities, resources, and physical spaces;
8) Multi-reachability or the ability for users to reach library spaces through a variety of routes;
9) Explorability (i.e., users are encouraged to move around the library); and
10) Stopability (i.e., users can stop and pick up materials at will).

These dimensions are not discreet – several overlap in meaning. Curiosity-invoking displays (3), striking contrasts (4), and pointers that remind users of their interests (5), for

example, all have the ability to capture attention. Unimpeded and direct access (1), multi-reachability (8), explorability (9), and stopability (10) could also be collapsed together as they all relate to exploration of resources. While the research stops short of verifying whether the divergent behaviour prompted by the environment led to serendipity, the dimensions are significant, representing the first attempt to identify specific characteristics of an information-rich environment that influence divergent behaviour and (potentially) serendipity. Just as characteristics of the individual appear to make them more likely to have serendipitous experiences, Björneborn's (2008) research suggests certain environments may also be more conducive to serendipity.

Other research has also indicated characteristics of the environment that may influence serendipity, primarily qualitative research on information seeking and serendipity, in which patterns of environmental features were identified across examples of serendipitous experiences. These themes, explored in the following sections, include the broader environment themes of explorative, diverse and information-intense, and social, as well as more specific descriptions of content within an environment including interesting or useful and unexpected or surprising. These themes overlap, just like Björneborn's (2008) serendipity dimensions but will be conceptually pulled apart, recombined, augmented, analysed, and tested throughout this thesis. They are, however, clustered in the following sections as they were identified in the prior research.

Explorative

Environments known for exploration, browsing, and discovery are often associated with serendipity. Interviews on the information needs and search strategies of four artists, for example, revealed that for artists, "happy accidents occur in the studio while working with their various media" (Cobbledick, 1996, p. 362) rather than a library. However, one of the most common environment-centric associations made with serendipity is that of browsing the library stacks. Marchionini (1995), for example, proposed that serendipity is precipitated by "open stacks in libraries and cross-disciplinary colloquia" (p. 105) as it exposes individuals to new methodologies, perspectives, and metaphors that may apply to their own work. Likewise, interdisciplinary scholars attribute chance encounters with information to the organizational structure of libraries that juxtapose sources from

different disciplines (Foster & Ford, 2003). In interviews with 22 graduate students in history about their information seeking, the students reported relying on serendipity while browsing – stumbling upon misshelved books, for example, that turned out to be useful (Delgadillo & Lynch, 1999). In a case study of an information seeker, browsing the library stacks was found to lead to an interruption and type of task-switching behaviour that Spink (2004) refers to as *serendipitous browsing,* in which "the information seeker physically browsed the library shelves for other information tasks" (p. 344). Björneborn (2008) also noted this type of divergent behaviour in his observation of library patrons; for example, an information seeker may start browsing in one area such as the DVD section and switch to browsing in another such as the magazine section.

Of course environments other than libraries are conducive to exploration and discovery. In interviews with 20 local newspaper readers, individuals reported being incidentally exposed to news via traditional and alternative news media websites, email, non-internet sources (e.g., television, radio, magazines, other people), and social networking sites as well as through sites that appear designed for non-purposive incidental exposure to online news such as StumbleUpon and Digg (Yadamsuren & Erdelez, 2010). Interviews with nine architectural students indicated that information encountering is facilitated by exploration (Makri & Warwick, 2010) and thus Makri and Warwick suggest that exploring and encountering may be supported in digital environments through the provision of alternative image search tools that do not follow the traditional keyword search template as well as social media tools for users to organize, share, tag, and rate digital objects such as websites and images.

Diverse and Information-Intense

Closely associated with environments that facilitate exploration and discovery are environments with a diversity of resources (Björneborn, 2008) and which are information-intense (Eredelez, 1995). As previously noted, having a diversity of active interests appears to increase the frequency of serendipity (Lee, 2009; Pálsdóttir, 2010). Likewise, an environment that facilitates serendipity has been associated with environments that contain a diversity of resources, information, or people willing to communicate or share information and resources. Three main and overlapping

environments have been identified as conducive to information encountering, including *printed environments*, *people environments*, and *internet environments* (Erdelez, 1995). What all of these environments have in common is that they are information-intensive (Erdelez, 1995). Sun et al. similarly found in a diary study of PhD students that places designed to deliver a diversity of information, such as libraries and lecture rooms support serendipity as well as work environments such as resource-rich training spaces and offices (Sun et al., 2011).

Social

As previously mentioned, Erdelez (1995) identified *people environments* in her PhD research as one of the main types of environments conducive to information encountering. People environments are those where individuals can encounter people who are in turn sources of encountered information. While information encounters may and often do occur in isolation (McBirnie & Urquhart, 2011; Sun et al., 2011), it appears often the case that serendipity is precipitated or mediated through interactions with other people (e.g., Foster & Ford, 2003; McCay-Peet & Toms, 2010; Pálsdóttir, 2011; Sun et al., 2011). Historians, for example, indicate their reliance on colleagues and archivists to help them make associations between information buried deep in archives and their own knowledge and interests (McCay-Peet & Toms, 2010). Some interdisciplinary scholars also attribute chance encounters with information to other people including librarians (Foster & Ford, 2003). Similarly, PhD students find serendipity occurs when socializing in-person with colleagues and professors and attending talks and presentations (Sun et al., 2011).

In an ethnographic study that included observations of 24 nurses' interactions with 108 seniors at multiple clinics as well as interviews with these nurses and seniors, Pettigrew (1999) identified *information grounds* as a physical space in which socially driven information encountering occurs. A health clinic, for example, is an information ground, "an environment temporarily created by the behaviour of people who have come together to perform a given task, but from which emerges a social atmosphere that fosters the spontaneous and serendipitous sharing of information" (Pettigrew, 1999, p. 812). That is, an information ground provides a space for learning about resources without the need for

people to explicitly ask for resources. Older adults and the elderly often encounter information when they are not explicitly looking for it and often through everyday interactions with other people (Pálsdóttir, 2011; Williamson, 1998). Interviews with 24 elderly people, for example, revealed that they opportunistically discover information through discussions with relatives and other social interactions in information grounds such as a union for the elderly and a sewing club (Pálsdóttir, 2011). This mirrors Williamson's (1998) finding from her study of 202 older adults' information seeking behaviour using interviews and telephone diaries in which both purposeful and incidental information acquisition occur through interactions with family, friends, as well as involvement with volunteer associations, churches, and clubs.

Similar to the phenomenon of information grounds, the online social media environment has been described as "an extension of social engagement with a CoP [Community of Practice]" that facilitates serendipity (Dantonio, 2010, p. 52). Through interviews with 15 post-graduate students, Dantonio found that students were not only aware that social media can lead to their own serendipitous experiences but are also cognizant of the notion of reciprocity in social media spaces; students may serendipitously discover information, but they may also share information, creating potentially serendipitous experiences for others.

Content: Useful and Unexpected

A necessary component of all potentially serendipitous environments is the presence of content – knowledge, information, ideas, objects. Empty white rooms with blank walls and devoid of anything will not do. Therefore, another common theme in the serendipity-related research relates more specifically to content contained within a given environment, namely, useful and unexpected content. Useful and unexpected are often joined together to describe the content with which individuals interact during a serendipitous experience. Relative to libraries, the misshelved book – an unexpected find – is often cited as serendipitous if it is also interesting or useful. Delgadillo and Lynch (1999) noted the serendipitousness of misshelved books in their research on historians' information seeking behaviours and Björneborn (2008) referred to misshelved books as one aspect of a serendipity dimension – imperfections in the library. Foster and Ford

(2003) noted that the unexpectedness in a serendipitous experience may be related to the existence or location of information as well as the value of the information found. It is not enough to be unexpected; content needs to be useful, connected in some way to the individual's knowledge, experience, and interests. As previously noted, opportunistic discoveries of information by the elderly, for example, are often related to health, formal support, and finances which reflect their everyday life problems and concerns (Pálsdóttir, 2011). Ross (1999) found that while readers may make an active choice regarding what they read, in the process of reading they report serendipitously encountering text that is helpful to them in their own lives. Researchers in Computer Science have, in particular, honed in on helpful or useful content characteristics to help foster serendipity in digital environments.

Due to the tight connection between content that is related to an individual's interest space, personalization has been proposed to support serendipity in digital environments and preliminary studies suggest it may facilitate it (André, Teevan, & Dumais, 2009; Campos & Figueiredo, 2002). Individuals often feel overloaded by information (Bellotti et al., 2008) and devices that are context-aware, a form of personalization, reduce the amount of information without suppressing content that may be considered interesting. Campos and Figueiredo (2002) designed Max, a web-based software agent, to test whether it is possible to *program* for serendipity. Max was designed to deliver unexpected and interesting information somewhat distanced from the current focus or interests of users. While participants (N=9) reported that most of the suggestions either were webpages known to them or webpages previously unknown to them but of little interest, Max showed some signs of supporting both pseudo serendipity and some level of serendipity, suggesting that it is possible to program for serendipity. Participants, however, were never asked directly about their perception of serendipity relative to Max and the sample size is too small to draw any significant conclusions.

2.4.3 Digital Environments

One of the main objectives of this thesis is to identify how serendipity may be facilitated in *digital environments*. Peppered throughout the preceding sections were references to research that examined digital environments. However, no studies to date have explored

and tested what features of these digital environments facilitate serendipity or have made comparisons among the efficacies of different types of digital environments to foster serendipity. Moreover, there are no instruments to test these relationships. While a tool to measure creative environment perceptions exists (Mayfield & Mayfield, 2010), no comparable tool to measure serendipitous environment perceptions has been developed.

2.5 Theoretical Framework

Information needs, seeking, and use models are characterised by their often purposeful, problem-solving frameworks. For example, "Information-seeking is a special case of problem solving. It includes recognizing and interpreting the information problem, establishing a plan of search, conducting the search, evaluating the results, and if necessary, iterating through the process again." (Marchionini, 1989, p. 54). One example of a goal-oriented model is Ingwersen and Järvelin's (2005) interactive information seeking and retrieval (IIS&R) in context framework (also referred to as cognitive IS&R). While Ingwersen and Järvelin proposed that the central factor affecting IIS&R is the intentionality of the information seeker, the conceptual framework includes many forms of information interaction, not only information seeking (Ingwersen & Järvelin, p. 306). I chose to situate the current study within the IIS&R framework. The incidental, accidental component of some instances of serendipity may be antithetical to intentionality, however, there is room for the phenomenon of serendipity within this model and research conducted within the framework of IIS&R in context has been fruitful and has generated significant research questions (Talja, Tuominen, and Savolainen, 2005).

The IIS&R framework is founded on the cognitive viewpoint in information science (Ingwerson, 1996). Belkin (1990) writes that the cognitive viewpoint "explicitly considers that the states of knowledge, beliefs and so on of human beings (or information-processing devices) mediate (or interact with) that which they receive/perceive or produce" (pp. 11-12). Cognitive IS&R brings together two related though divergent research areas, information seeking (IS) and information retrieval (IR), under a single framework. IS and IR rarely work together despite the advantages of such a partnership (Ingwersen, 2005). While IS comes from the library and information sciences tradition and predominantly uses social science approaches, IR is more squarely rooted in the

computer sciences and primarily uses the laboratory-based approach (Ingwersen & Järvelin, 2005). IS and IR have thus taken two different directions "and it is safe to say, that one camp generally views the other as too narrowly bound to technology whereas the other regards the former as an unusable academic exercise" (Ingwersen & Järvelin, 2005, p. 2).

The IIS&R in context framework was developed from an earlier model of interactive information retrieval by Ingwersen (1992) and includes key elements of the cognitive viewpoint with a specific emphasis on context and integrates research and theoretical models from IS and IR. The cognitive viewpoint in information science has been in development since the 1970s with its introduction by B.C. Brooks in 1975 and Mark De Mey in 1977. The cognitive viewpoint itself was influenced by cognitive scientist Jean Piaget's work since 1929 on the development of cognitive structures as well as the socio-linguistic work of Alexander Luria from the 1920s that indicated that the way individuals classify information is influenced or triggered by their knowledge, their routines and situations encountered (Ingwersen & Järvelin, 2005). The IIS&R framework integrates this cognitive viewpoint with research and models developed in the 1990s primarily relating to information seeking, relevance, and task. The framework was informed by Kuhlthau's (1991) stages of the information seeking process which integrated physical activities, feelings, and thoughts, relevance models developed by Saracevic (1996) and extended by Spink, Greisdorf and Bateman (1998), and task stage (Vakkari & Hakala, 2000) and task complexity (Byström & Järvelin, 1995) (Ingwersen & Järvelin, 2005). The framework includes, for example, the "emotional/affective perceptions and structures" (Ingwersen & Järvelin, 2005, p. 259) which were first introduced to information seeking studies by Kuhlthau.

The interactive IIS&R in context framework (Ingwersen & Järvelin, 2005) focuses on interactions between cognitive actors, context (organizational, social, cultural), information objects, and information technology as well as those mechanisms (e.g., computer interface) that at times mediate these interactions. The five main components of Ingwersen and Järvelin's (2005) framework are defined as follows:

A) Cognitive actors: Cognitive actors are those "responsible for the interpretation or provision of potential information or signs represented as information objects, IT, interface functionalities and during communication" (p. 382). Cognitive actors include, for example, the author of an information object, the interface designer, the communities of individuals in an organizational context, or an information seeker.

B) Social, cultural, organizational context: Cognitive actors act within a social, cultural, and organizational context. Context includes, for example, the domains, goals, and work tasks of an organization in which the cognitive actor works and the strategies, preferences and interests embedded within the organizational culture.

C) Information objects: The digital entities that reside in information retrieval systems such as text documents and images. They provide potential information for the cognitive actor and are also referred to as sources.

D) IT (information technology or system architecture): IT is "concerned with the IR system's information technology architecture, i.e., primarily the algorithmic structures, retrieval model, computational logic and database design" (p. 387).

E) Interface: The interface is the "mechanism located as the go-between two electronic or human components of an information system" (p. 386).

Cognitive actors act within and influences and is influenced by their social, cultural, and organizational context as well as their systemic context (information objects, interface, and information technology). Different cognitive actors all communicate at different points in time and space during IIS&R (Ingwersen & Järvelin, 2005). Though abstract and not designed to be a process model, the IIS&R framework endeavours to be concrete by ensuring that all five components above have "tangible entities". For example, information objects and IT each have tangible entities such as document text and algorithms that allow for direct observation. The IIS&R framework makes room for the cognitive actors' – whom I refer to as indiviuals in this thesis – *perceptions* through the "cognitive-emotional level" of the framework that mirrors its "social and physical level" (Ingwersen & Järvelin, 2005, p. 278).

Serendipity is embodied in the interactions among the five main elements of the IIS&R in context framework at both levels – the cognitive-emotional and the social and physical levels. Of particular value with respect to my serendipity research are the *perceptions* of the "systemic context" – the information objects, interface, and IT (engines, logics, and algorithms) of the digital environment. Within this framework, we can test the hypothesis, for example, that perceptions of digital environments influence individuals' perceptions of serendipity. Examining these perceptions have the potential to help us connect perceived characteristics of the digital environment with the tangible entities of the digital environment, thus informing requirements for the design and development of digital environments that support serendipity.

IIS&R's emphasis on the individual is useful due to the subjective nature of serendipity. IIS&R also recognizes the role of context in individual cognition: "The perception, interpretation and cognition of the individual actor is *determined* by its/his/her prevailing cognitive structures – and *influenced* but *not* directed or dictated by the environment or domain" (Ingwersen & Järvelin, 2005, p. 31). Moreover, the framework is flexible. IIS&R may be applied to studies involving a variety of cognitive actors (e.g., scholars, end-users of websites) and systemic contexts that may or may not include computer interfaces but rather direct interactions with non-digital documents, information, or objects. Interactions, for example, may take place between a scientist and a natural phenomenon and still fit within a modified IIS&R framework (see Ingwersen & Järvelin, 2005, p. 273). Situating the current study within IIS&R in context, therefore, allowed for the exploration of a wide range work-related serendipity while helping to ensure that the findings inform the development of digital environments to support serendipity.

2.6 Summary

In the preceding review of the prior research, I discussed serendipity as well as several factors that may influence serendipity relating to individual differences and the environment. Situating this research within the cognitive IIS&R in context framework (Ingwersen & Järvelin, 2005) allows for the exploration of all of these key variables – the individual, the information, ideas, objects or phenomeon, and the environments that mediate their interactions. The research relating to serendipity has primarily

focused on a specific aspect of serendipity – the information behaviour surrounding information encounters. While research points to a more robust model of serendipity, many gaps still exist in our knowledge. While connections have been made between serendipity, individual differences, and characteristics of the environment, few empirical findings support them. Very little empirical research has been pursued examining the role of individual differences in serendipity such as openness to experience, extraversion, and locus of control, despite indications from the research across a variety of disciplines that suggest they merit further exploration. As well, while previous investigations have identified characteristics of the environment that may support serendipity, characteristics such as explorative and social, these have yet to be operationalized and tested in the context of digital environments. Furthermore, while prior research on creativity indicates potential interactions between personality and environment (Oldham & Cummings, 1996), no studies to date have explored this type of interaction relative to the phenomenon of serendipity and, as yet, no tools have been developed to measure serendipity-related constructs such as the serendipitous environment that will help to explore these relationships.

CHAPTER 3. RESEARCH DESIGN

3.1 Research Design Overview

This research was conducted in three phases using mixed methods and a sequential exploratory strategy. Phase 1 began with a review of the prior research as well as an investigative study to develop a conceptual model of the process of work-related serendipity and discover what may influence it. In Phase 2 I drew from and elaborated on Phase 1 findings to construct a questionnaire on serendipity and the serendipitous digital environment (SDE) scale and test content validity of the SDE scale using qualitative and quantitative approaches. Phase 3 applied the measures developed in Phase 2 to explore relationships between factors hypothesized to influence serendipity and to assess the validity of the SDE scale. This chapter describes the research design approach, sources of data, the design of each of the three phases of the research, and the study population (see Figure 1 for overview).

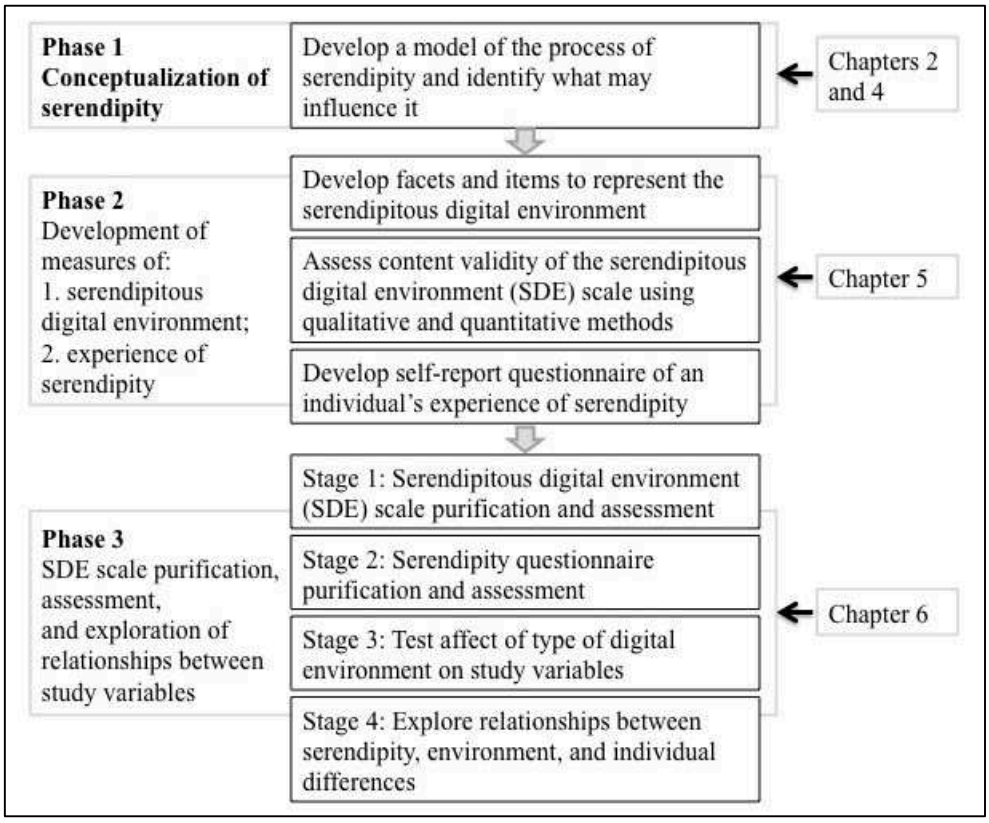

Figure 1 Overview of research design

3.2 Research Design Approach

The philosophical assumptions of this research are pragmatic in nature – the focus is on the research problem of work-related serendipity in digital environments and the practical implications of the research rather than an adherence to a single set of methods or philosophical viewpoint. Creswell and Plano Clark (2007) note that the central premise of mixed methods "is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone" (p. 5). A sequential exploratory approach (Creswell, 2003) was selected, characterized by qualitative studies followed by quantitative studies. A mixed methods approach allows for inductive and deductive techniques and comparisons between qualitative and quantitative findings. As well, the sequential exploratory approach is particularly useful in the design, development, and testing of an instrument (Creswell & Plano Clark) which was one of the objectives of this research.

3.3 Sources of Data

This research used both primary and secondary sources of data. Primary data was gathered through semi-structured interviews (Study 1) and an expert review (Study 2) and by administering the ANOVA approach (Study 3) and multiple questionnaires (Study 4). Secondary data was gathered through a review of the prior research across multiple disciplines.

3.4 Research Design

The three phases of research are presented in several chapters of this thesis:

> **Phase 1** – Conceptualization of serendipity (Chapter 2 and Chapter 4)
> **Phase 2** – Measuring the serendipitous digital environment (SDE) and serendipity (Chapter 5)
> **Phase 3** – SDE scale and serendipity questionnaire assessment and exploration of relationships between serendipity, individual differences, and the environment (Chapter 6)

An overview of the three phases of this research including the research questions they address, approaches and methods, and types of data analyses is explained in the sections that follow.

3.4.1 Phase 1: Conceptualization of Serendipity

This phase of the research was designed to gain an understanding of work-related serendipity and to establish the conceptual or theoretical foundation for the development of a measure of the serendipitous digital environment.

The main research question (RQ) for this initial phase was:

> ***RQ1*** *How does work-related serendipity unfold and what aspects of the individual and the environment are likely to influence this process?*

Phase 1 laid the groundwork for the development of a self-report instrument designed to measure a potentially serendipitous digital environment as well as more direct measures of serendipity in Phase 2. This conceptualization phase is vital to the development of a measure (MacKenzie, Podsakoff, & Podsakoff, 2011), but the use of these measures in Phase 3 also made it possible to test relationships between serendipity and a variety of factors that may influence it – environmental factors and factors relating to the individual. Phase 1 consisted of a review of the prior research (Chapter 2) and an investigation of work-related serendipity using semi-structured interviews with 12 academics and professionals who had at least one example of serendipity related to their work to explore in depth (Chapter 4). Thematic analysis of the interview transcripts was conducted.

3.4.2 Phase 2: Development of Measures

The main research question addressed in Phase 2 was:

> ***RQ2*** *How do we measure the characteristics of a digital environment that have the potential to support serendipity? And what are these characteristics?*

Research Question 2 was addressed through a conceptualization of a serendipitous digital environment through deductions from findings from Phase 1, two consecutive studies to test content validity – an expert review (DeVellis, 2003) and an ANOVA approach (Hinkin & Tracey, 1999). An expert review was conducted with a set of eight international researchers – experts in serendipity-related research. This qualitative study was designed to hone the definitions of the facets, the facet items, identify other potential facets, and ultimately assess the content validity of the preliminary SDE scale. The second content validity approach used is what Yao, Wu, and Yang (2008) refer to as the "ANOVA approach." Using this quantitative approach, 107 participants, predominantly

students, rated how well each of the SDE items captured the gist or meaning of each of the definitions of the facets of a serendipitous digital environment.

As well, the development of a direct measure of serendipity was needed to help assess the SDE scale; therefore a self-report instrument of the perceived frequency of serendipity was developed. RQ2 was further addressed in Phase 3 in which the construct validity of the SDE scale was tested using this measure of serendipity developed in Phase 2.

3.4.3 Phase 3: Scale Purification and Assessment and Exploration of Relationships

Phase 3 was designed to continue the development of a means to measure how well a digital environment supports serendipity but was also motivated by the need to discover what influences serendipity in digital environments and in general. In addition to RQ2, Phase 3 was driven by two research questions:

> ***RQ3*** *Does the type of digital environment in which an individual interacts influence serendipity? And are the perceived characteristics of that digital environment influenced by the type of digital environment?*
>
> ***RQ4*** *What relationships exist between serendipity and the underlying facets of a serendipitous digital environment, the individual's broader work environment, locus of control, openness to experience, and extraversion?*

Several hypotheses relating to these RQs were generated and are described in Chapter 6.

Using a web-based survey, multiple questionnaires relating to the individual and the environment were administered to 289 professionals, academics, and graduate students.

- Serendipitous digital environment (SDE) scale (developed in Phase 2);
- Serendipity questionnaire (developed in Phase 2);
- Creative Environment Perceptions scale (Mayfield & Mayfield, 2010);
- Locus of Control of Behaviour questionnaire (Craig et al., 1984);
- Openness to Experience questionnaire (Lee & Ashton, 2004); and
- Extraversion questionnaire (Lee & Ashton).

The SDE scale and the serendipity questionnaire were purified and the reliability of their subscales assessed. The inclusion of all the instruments listed above allowed for the exploration of the relationships between factors including types of digital environment.

EFA, multiple regression, and MANOVAs were used to analyze the data collected in this phase of the research.

3.5 Study Population and Focus Area

There are many different areas of human endeavor in which serendipity occurs. Any domain or setting, including science (McBirnie & Urquhart, 2011), interdisciplinary research (Foster & Ford, 2003), or everyday life (Rubin et al., 2011), could have been selected. The primary study population chosen was broad and included professionals, academics, and graduate students conducting thesis work for whom information seeking and monitoring and the application of information and knowledge are important parts of their work. This wide net was cast across multiple domains due to my interest in the information-centric phenomenon of work-related serendipity rather than a specific domain. Selecting a broad population – professionals and scholars – made it possible to recruit enough participants to enable the multivariate analyses in Study 4 – recruitment would have been very challenging if the sample population parameters had been narrower.

Work-related serendipity was the specific focus of this thesis because of my interest in making a contribution to research that informs the design and development of digital environments such as databases, intranets, and search engines that support scholarly and professional work. Prior research has generally focused on either serendipity in everyday life (Rubin et al., 2011; Pálsdóttir, 2011; Williamson, 1998) or work-related serendipity with primarily scholars (Foster & Ford, 2003; Makri & Blandford, 2012a; Sun et al., 2011) or scientists (Barber & Fox, 1958; McBirnie & Urquhart, 2011) as the study population. However, both everyday and work-related serendipity share underlying concepts as evident in the discussion of serendipity models in the preceding chapter. The distinction between everyday serendipity and work-related serendipity may be an artificial one, however, for the purposes of this research, the focus will be on work-related serendipity.

While the primary study population – scholars and professionals – was central to Studies 1 and 4 in which a conceptual foundation was laid and subsequently tested, the intermediate studies required two different study populations based on the objectives of

the research and practical concerns. Study 2 was an expert review; therefore, the study population was researchers with expertise in serendipity-related constructs. Like Study 2, Study 3 was also designed to test content validity, but the cognitive nature of Study 3's tasks did not require the use of the primary study population or experts in serendipity research. University students, therefore, served as the study population in Study 3, thus preventing the exhaustion of potential participants needed for Study 4.

3.6 Summary

The study population – academics, professionals, and graduate students engaged in thesis work – is appropriate for this research that seeks to understand work-related serendipity and how it may be supported in digital environments. The research was conducted in three successive phases, building on the findings in each to lead to a more holistic understanding of serendipity, the identification of what influences serendipity, and the development of a questionnaire to measure the potential of a digital environment to support serendipity.

CHAPTER 4. INVESTIGATION OF SERENDIPITY (STUDY 1)

4.1 Overview

This chapter reports on a study examining serendipity that, together with a review of the prior research (Chapter 2), comprised Phase 1 of this PhD research (see Figure 2). Interviews with 12 professionals and academics were conducted to collect data on work-related serendipity to better understand how the process of serendipity unfolds and what aspects of the individual and the environment may influence that process. This study used a semi-structured interview method that enabled flexibility in interviewer-interviewee interaction. While the scope of this research was limited to work-related examples of serendipity, the examples did not necessarily occur entirely in the physical work place, which reflects the often-blurred boundary between work and leisure. The thematic analysis method (Braun & Clarke, 2006) of the interview transcripts was employed. The methods and findings are presented in the following sections while the final section summarizes this study's key findings and outlines next steps.

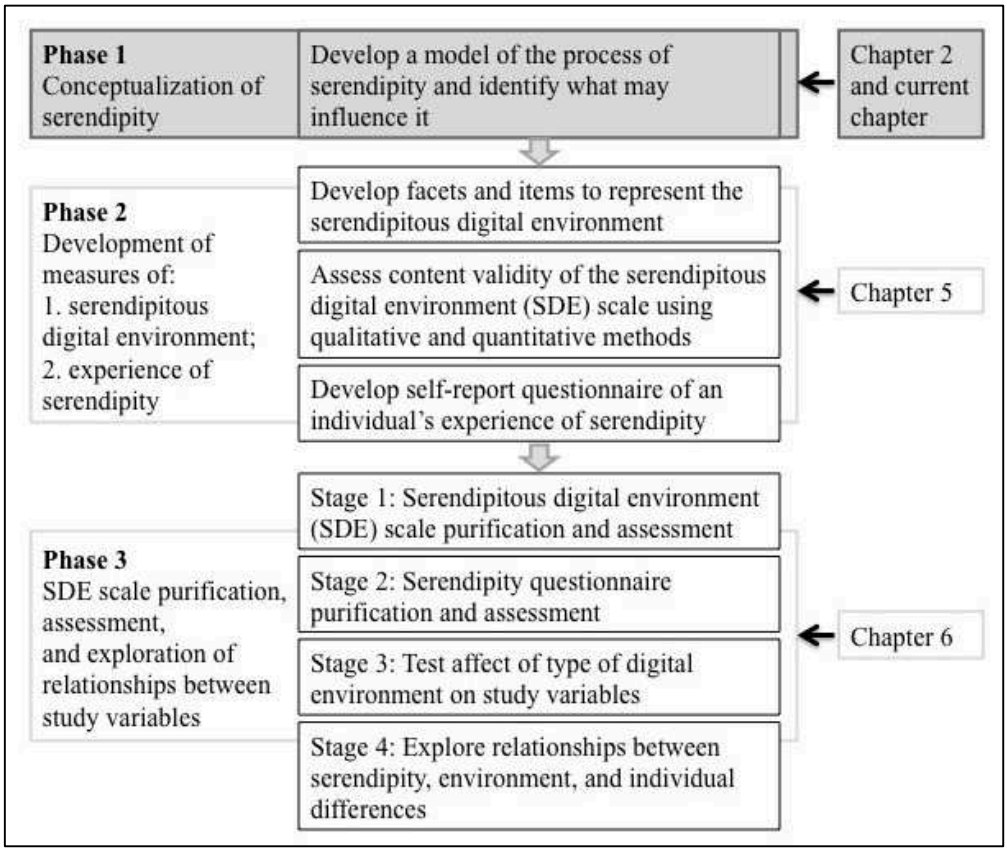

Figure 2 Current Chapter 4 in relation to study design

4.2 Research Question

Phase 1 was motivated by the following research question:

> ***RQ1*** *How does work-related serendipity unfold and what aspects of the individual and the environment are likely to influence this process?*

Several models of serendipity have been proposed in recent years – they complement each other and share many common elements (see section 2.2.3). This study seeks to identify the core elements of the process of serendipity as well as those most salient factors that shape how work-related serendipity unfolds. A review of the prior research (Chapter 2) explored three individual differences (openness to experience, extraversion, and locus of control) that may influence the process of serendipity as well as its perception. Furthermore, environmental conditions relating to the individual's broader work environment as well as the characteristics of specific digital environments have also been noted in the prior research as precipitating conditions of serendipity. This study sought to confirm and augment the prior research and, ultimately, identify which factors of the individual and the environment were most likely to influence the process of serendipity and thus also help to select variables to be included in the studies to follow.

4.3 Methodology

Ethics approval was obtained for this study from Dalhousie University's Social Sciences and Humanities Research Ethics Board (2010-2254).

4.3.1 Participants and Recruitment

Sampling for this study was non-probabilistic and quasi-purposeful. Participants from a variety of fields were sought by sending requests to various universities' mailing lists as well as targeting those whose serendipitous experiences have been reported through the media. See recruitment instrument in Appendix 2.1. The key criterion for participation was that participants have a memorable experience of serendipity relating to their work. A screening tool, an inclusion/exclusion questionnaire, therefore, was used to ensure that participants had at least one example of serendipity that could be explored in depth during the interview. The screening tool provided a common definition of serendipity and asked whether potential participants could briefly describe one or two serendipitous experiences, and to indicate how well they remember details surrounding these

experiences (Appendix 2.2). No honorarium or compensation was offered during the recruitment process. Data collection came to an end after the twelfth interview when the researcher identified recurring patterns in the examples provided by participants (Guest, Bunce, & Johnson, 2006).

Participants included seven females and five males, mostly between the ages of 46 and 65 (N = 9, 75%) and were drawn from across Canada. Participants came from a variety of fields: computer science, occupational therapy, journalism, education, English literature, information management (IM), creative writing, internal medicine, digital humanities, and molecular biology. The majority (N=8) held a doctoral degree and had worked in their fields for 6 to 42 years (M=22.3).

4.3.2 Interview Protocol

While concepts derived from prior research were used as the basis for some of the questions, effort was made to ensure participants' experiences were explored from different perspectives and not solely based on an exploration of predetermined concepts. To help accomplish this, questions were constructed to capture what Dervin (2003) refers to as the *situations, gaps, bridges,* and *outcomes* of an experience in relation to time and space. This approach was designed to allow concepts previously identified in the literature to be explored and challenged along with concepts that were not as strong or perhaps missing from the literature. The full interview protocol is in Appendix 2.3. There were four main lines of inquiry:

A) Work. Respondents were asked two main questions about their work: 1) Could you describe for me the type of work that you do? and 2) Could you describe your typical work tasks or projects? These questions and follow-up questions and probes were designed to prompt participants to think about their work environments, approaches to work, how they develop new ideas, and their work-related interactions with other people.

B) Definition of serendipity. Because the concept of serendipity is interpreted in many different ways, respondents were presented with two definitions of serendipity: 1) dictionary-like definition: "the art of making fortunate and unexpected discoveries by chance"; and 2) scholarly definition: "the fairly common experience of observing an

unanticipated, *anomalous* and *strategic* datum which becomes the occasion for developing a new theory or for extending an existing theory" (Merton, 1948, p. 506). Participants were subsequently asked: 1) Would you agree with these definitions? and 2) What would you describe as the key components or qualities of serendipity? These questions were designed to highlight the fact that there is no single definition, with the intent to free them to express their own perspective on the phenomenon.

C) Specific example of serendipity. In this main portion of the interview, one to two examples of serendipity relating to the participant's work were explored in order to ground the interview in specific, memorable serendipitous experiences rather than general views relating to serendipity. Participants were asked: Can you think of a specific time in your work life when you experienced serendipity? Responses to this interview question set the stage for a series of follow-up questions and probes designed to extract the details surrounding this experience. These follow-up questions explored what they were working on at the time, the associations that they made, their feelings, thoughts, actions, behaviours, outcomes, and supports and barriers relating to the experience. These details were designed to be useful for identification of the main elements of the process of serendipity as well as what influences it.

D) Serendipity in general. Finally, participants were asked to discuss serendipity in response to three questions: 1) Thinking about your own experience with serendipity in general, is there a common environment in which it occurs or common conditions? 2) How would you describe the product of serendipitous discovery in relation to your field of work? and 3) How would you describe serendipity in relation to your field of work? The first question essentially asked participants what they perceive to be the facets of the serendipitous environment, allowing participants to expound more generally on what aspects of the environment influence serendipity. Given the diversity of participants' backgrounds, the purpose of the second and third questions was to gain an understanding of potential differences in the perception of serendipity across a number of domains.

4.3.3 Procedure

Participants were recruited and administered an inclusion/exclusion questionnaire; those who fit within the parameters were subsequently interviewed within a three-month period

from July to October 2010. Each 45 to 75 minute interview session followed the same process: an interview was conducted by telephone or in-person in the researchers' lab, in a coffee shop, or the participant's office; the research problem was presented to the participant who then signed a consent form that noted the problem of protecting anonymity given the personal and unique situations that would be discussed (Appendix 2.4); each participant completed a demographics questionnaire that was designed to obtain a basic profile of the respondents (Appendix 2.5); and each participated in an audio-recorded interview and filled in and signed a follow-up consent form (Appendix 2.6).

4.3.4 Data Analysis

Each interview was professionally transcribed and loaded into NVivo 9 software for analysis using a thematic analysis method described by Braun and Clarke (2006). I was the sole interviewer and conducted several iterations of data analysis. Codes were generated inductively, though some codes were influenced by those concepts identified in the preliminary model of serendipity (McCay-Peet & Toms, 2010, adapted from Cunha, 2005). Codes such as *hard work, learn more*, and *taking a break*, for example, were inductively developed and had no origin in the preliminary model. Other codes, such as *verbal trigger* and *making associations between what was known and what was found* both reflected and enhanced themes identified in the preliminary model. As data analysis progressed, definitions for codes were developed and were then used to deductively code the transcripts. Codes, and the themes identified through these codes, were reviewed by extract as well as the entire data set to ensure consistent application. As a result of this process, some elements from the preliminary model were altered (e.g., *bisociations* became *connections*) or removed (e.g., *search for a solution to task A*) to better reflect themes identified in this set of data. Because data analysis began before the three other models of serendipity (Makri & Blandford, 2012a; Rubin et al., 2011; Sun et al., 2011) (see Section 2.2.3) were published, codes and themes were developed independently of these three models. Analysis continued as I wrote this thesis when theme examples were extracted and subjected to further analysis as they were related to the research question and the prior research.

Creswell (2007) recommends using at least two validation strategies. Those selected for this study include clarification of researcher bias, peer debriefing, and the provision of rich, thick description. Researcher bias is made clear through the indication of prior work examining the process of serendipity (McCay-Peet & Toms, 2010; Toms, 2000) and the disclosure of the researchers' assumption that serendipity is not merely luck or accident. Peer debriefing occurred within the serendipity research community. Peer debriefing was used to "critically examine what is disturbed and shaken loose during the research process" (Manning, 1997, p. 104). To confirm the analysis, partway through the coding procedure a research assistant with no expertise in serendipity research coded a selection of six transcripts using rich code definitions. All disagreements were discussed, codes and themes refined, and definitions clarified. Finally, in line with Creswell's recommendation of rich description, examples of serendipity were described in enough detail that the potential transferability of the model to other domains is demonstrated.

4.4 Findings

Drawing from their diverse work-related experiences, the twelve participants described fifteen examples of serendipity. Some of the experiences had occurred many years ago while others were recent and their full outcomes unknown. A brief summary of each example is provided in Table 3. Examples are referred to according to participant numbers (e.g., P1) and an additional "a" or "b" is added for those participants who described more than one example (e.g., P2a). For each example, what prompted the experience, how it progressed, and was realized were isolated for analysis.

Table 3 Summary of participants' examples of serendipity

Participant	ID	Example
Digital humanities scholar	P1	Stumbled upon software that provided a new approach to studying the history of the book and led to a new research path.
Information manager	P2a	A chance meeting with a colleague on a bus provided an unexpected career opportunity.
	P2b	During lunch at a conference, a colleague unexpectedly offered an idea to improve the organization's search system.
Occupational therapy professor	P3	A chat over coffee with her boss led her to make an important connection between her work and that of a student and mentee.
Medical doctor	P4	An unexpected opportunity to interview for a residency changed the course of his life.
Occupational therapist/ therapy scholar	P5a	She found a new way to conceptualize her profession that had global implications.
	P5b	She was exposed to the notion of getting a masters education by distance that prompted her to take an unexpected path.
English literary scholar	P6	She found an incorrectly indexed manuscript that turned out to be a very important and previously unknown collection of a poet's work.
Education scholar	P7	She made a connection between water and her research on civility that led to an international collaboration to reduce water conflict globally.
Molecular biologist	P8	While skiing, she observed insects hopping on the snow that she later tested and found contained effective antifreeze proteins.
Creative writer	P9	While en route to a funeral, she spotted a phrase spray painted under an overpass that became the basis for her first book of fiction.
Journalist	P10	Stumbled upon an unsubstantiated claim in Wikipedia about the origin of an internationally famous song that led him to discover a near-forgotten piece of local history.
Computer scientist/ professor	P11a	Following a research talk he gave, a PhD student in the audience led him to a solution to a problem he may not have made on his own.
	P11b	Students brought a paper containing a puzzling formula to his attention that reminded him of another student's problem from 15 years earlier –further problem solving and analysis led to a new explanation.
Information management professor	P12	He happened to look up at his screen that displayed his Twitter Deck just when a tweet appeared with a link to slides that he found relevant and he was able to use in an upcoming class lecture.

4.4.1 Main Elements of the Process of Serendipity

This section explores what key elements underlie serendipity. Five main elements of the process of serendipity were identified in all 15 examples of serendipity through deductive and inductive coding, as explained in the data analysis section: Trigger, Connection, Follow-up, Valuable Outcome, and Unexpected Thread. The five elements (Table 4) describe the process of serendipity: *what* triggered serendipity; *what* connections were made; *what* follow-up activities ensued; *what* the outcomes of serendipity were; and, finally, *what* the unexpected aspect was.

Table 4 Main elements of the process of serendipity

Element	**Definition**
Trigger	A verbal, textual, or visual cue that initiates or sparks serendipity.
Connection	The recognition of a relationship between the *Trigger* and the individual's knowledge and experience.
Follow-up	The actions an individual takes to pursue *Triggers/Connection* and obtain a *Valuable outcome*.
Valuable Outcome	The positive effect(s) evident within the process of serendipity.
Unexpected Thread	The unexpected, chance, accidental, or surprising element that is evident in one or more of the four other elements of serendipity.

To illustrate the five elements in one example, the occupational therapy professor's (P3) serendipity was *triggered* during a conversation with her boss over coffee. She was lamenting that she wanted to attend an upcoming conference but none of her research was ready to submit. While talking about her student's as well as her mentee's research she suddenly made a *connection* between their findings and her own research, a significant revelation that had not been previously identified in the literature. She *followed-up* by reviewing the literature to ensure its novelty and subsequently wrote and submitted an abstract for the upcoming conference. On a personal level there were two main *valuable outcomes*: 1) at the time of the interview the abstract had been accepted and she was excited that she would be able to go to the conference after all, and 2) she considered this serendipitous experience to be a highlight of her year. Moreover, due to the recency of the experience, she anticipated further *valuable outcomes* including, a contribution to the

knowledge with potential ramifications for research and practice. The *unexpected thread* wove through the trigger, connection, and follow-up elements. The research findings themselves were unexpected (trigger) as were the fact that the various findings were related (connection). Also unexpected was the collaboration itself (follow-up) which she indicated was highly unusual in her field.

4.4.1.1 Trigger

Where does serendipity begin? When simply asked to describe their serendipitous experiences, participants first put their story into context, describing what they were doing in the moments or days leading up to a key moment that set off a memorable series of events. There was no discernable pattern of activity across all participant examples (e.g., searching for information), but in that key moment there was something *external* to them, some*thing* that served as a catalyst for a turn of events in an otherwise normal day. That something, that *Trigger,* was a visual, textual, or verbal cue that initiated or prompted serendipity. The digital humanities scholar (P1) noted that for serendipity to occur, "There obviously has to be *something that… creates the thinking in me* – that there's *something* relevant there." An individual's interaction with some aspect of the environment is necessary. What we observe and interact with – what we see, hear, or read – has the potential to spark serendipity. Three forms of Triggers were identified: A) verbal, B) visual, and C) textual.

A) Verbal Triggers: The social aspect of serendipity, the notion that serendipity springs from interactions with other people, was readily apparent in many of the experiences described by participants. When thinking about her own experiences, the creative writer (P9) mused that "serendipity can be just you and the thing, but a lot of the time it is somebody *saying* something" – a verbal Trigger of serendipity. The digital humanities scholar (P1), for example, stumbled upon a new approach to studying the history of the book through a playful conversation with her husband about his work with a type of software. Thinking she recognized a photograph on his computer screen,

> I simply said, "what's that?" and he responded not about the photograph but about the totality of what he was working on. And he said, "*it's particles of soil moving through the air above the Prairies*", and I

> immediately said, teasing him *chuckling*, "oh, that's so boring, I'd only be interested if it was books on ships moving across the Atlantic." And [Bob] immediately teased me back and said, "*well don't be so foolish*." And I thought, "it could be books on ships moving across the Atlantic, the software doesn't care". *laughing* And that was a eureka moment for me.

What the scholar's husband said to her during this brief exchange was the catalyst for helping her think about software that she had known about for years in a different way. Many of the Triggers reported by participants were similarly part of conversations with work colleagues or supervisors.

B) Textual Triggers: Participants also often noted textual elements in documents, webpages, and objects. The English literature scholar (P6) who chanced upon a mis-indexed manuscript containing a thousand pages of a poet's complete work recalled:

> What caught my attention, *it was like a flash. I started reading it*, opened it fairly randomly, started reading and immediately thought this is not 1787 because I could tell by the references in the poem that it […] was roughly 1820s.

The textual trigger appeared in this case in a manuscript. Other examples included text within a Wikipedia article (P10, journalist), a scientific paper (P11b, computer science professor), a tweet on TwitterDeck (P12, IM professor), and graffiti – what the creative writer (P9) referred to as "found text." Text, in various physical and digital forms, provided the fragments of information, informative or inspirational, that prompted serendipity.

C) Visual Triggers: Less common in the examples described by participants were visual Triggers – something non-textual in nature that was the catalyst for a serendipitous experience. The molecular biologist (P8) saw insects hopping on snow, a visual cue that prompted her to collect a sample of the insects to take back to the lab for testing which in turn expanded the field's understanding of anti-freeze proteins. The other case of a visual Trigger sparking serendipity was less easy to tease out from other potential Triggers. The education scholar (P7) could not pinpoint a specific moment in time in which she began thinking about water in relationship to her own work, but the scholar felt certain that her close proximity to a lake was critical to her serendipitous experience: "nature in my case,

just being by the water, being near such an opportunity to focus and concentrate on it. Had I not been living there I do not think it would have occurred to me." The Trigger, the lake, in her example may have been visual – or, "being by the water*"* may be interpreted as a more robust, all-sensory experience.

For two of the participant examples (P3, P5a) it was difficult to pin point just one Trigger. The occupational therapy scholar (P5a) described a cascading set of activities such as observing, reading, writing, and discussing rather than any tangible Trigger. In the case of the occupational therapy professor (P3), she noted reading about a particular finding in her masters student's work (textual Trigger?), talking with him about the finding over lunch (verbal Trigger?), talking with him and one of his thesis readers about both of their similar findings (verbal Trigger?), and then finally the tipping point when talking with her boss about the findings over coffee (verbal Trigger?) before realizing that she had a similar finding and that she could tie it all together in time to submit an abstract to a conference.

> I'd noticed it before in [John]'s work, so I had noticed it, I hadn't ignored it. I just hadn't seen it in my own work. I hadn't framed my own work that way. Although it is funny because you'll see a poster out there and it is right clear through the poster, that I wrote some time ago, about last year at this time. So it has been percolating, but I just didn't see it, couldn't pull it together.

There was a delay in serendipity evident in this example that suggests that Triggers sometimes need time to percolate or bubble, perhaps with the help of cues that echo the initial Trigger but may come in different forms and lead to a clarity of understanding.

4.4.1.2 Connection

Connection is defined as *the relationship* between the Trigger and the worker's knowledge and experience. The molecular biologist (P8) described the Connection between the Trigger and her knowledge and experience relating to insects:

> We don't find that many of them have antifreeze proteins. But if they are active at sub-zero temperatures then […] there is a higher probability that they are going to have those proteins. So the thing really is, 'oh, it is below zero and they are moving'. And so that is sort of a clue.

As this passage suggests, the Connection between the Trigger and knowledge and experience was crucial. These biologists know what to watch for – insects that are active in sub-zero temperatures – experience tells them this. Knowledge and experience increases their chances of finding insects that will have the anti-freeze proteins they seek.

While Connection refers to the related entities, two subthemes of Connection were identified that point to the nature of the relationship. These include: 1) known problem connection in which there was a relationship between the Trigger and the worker's previously identified or current problems; or 2) new direction connection in which the relationship was between the Trigger and new, previously unidentified work-related opportunities or directions. In both cases, known problem and new direction, the relationship or Connection was within a work context. While the former has the potential to solve a prior problem or need, the latter opens up opportunities to pursue previously unidentified work-related problems or interests.

The passage above from the molecular biologist (P8) exemplifies the known problem connection while the following passage illustrates a new direction connection. When the education scholar (P7) was asked if water, the Trigger for her serendipitous experience, had anything to do with what she was working on at the time, she replied:

> Not at all directly, but it was one of those unexpected and kind of circuitous links. Because I was teasing apart and reconstructing areas of human behaviour that were showing prior conflicts and potential destructive behaviours, that line of thinking, that also translated into my thinking about my relationship around water.

Prior to making a Connection between water and her own area of research, water had not entered her problem space in relation to her own work. Therefore, the Connection she made represented a relevant but new direction for her work.

4.4.1.3 Follow-up

The Connection invariably set off a series of actions designed to make the most of it and reflects the active quality of serendipity in the context of work. These actions varied in granularity, depth, and in importance, but are presented here under the umbrella of *Follow-up*. However fortunate, interactions with Triggers do not in and of themselves constitute serendipity in the context of work. This is aptly noted in this observation by the

molecular biologist (P8): “It is one thing to observe it, the phenomenon, but with every time you do that *you have years of work* trying to figure out what is going on there.” The Trigger needs to be handled in some manner; the verbal, textual, or visual cue has only been perceived and a preliminary Connection made. Several types of Follow-up activities were identified in the examples of serendipity. These included: A) capturing, B) opportunity taken, and C) preparation for application.

Capturing involved the practical ways in which they had to manage or handle the Triggers themselves before being able to fully use them or in order to allow them to be retrieved later, including saving the Trigger for later use through emailing, recording, bookmarking, photocopying or otherwise ensuring access to the Trigger at a later time. For those introduced to opportunities for study and work, the Follow-up was rather straightforward – participants had to *take* the opportunity presented to them. Finally, preparation for application or use of the Trigger/Connection was the most common form of Follow-up. This was evident in the example provided by the journalist who came across an unsubstantiated claim on Wikipedia (P10):

> […] my editor was saying, 'well, if this is a speech he made a hundred times and just happened to remake it in [Town], then we are not that interested’. So to prove as best I could that this was the first time that the speech had been made, it was specifically made to people in [Province].

The journalist could not base an article around an unsubstantiated claim – he had to corroborate it to ensure the story was not only legitimate but also significant. While the participants had a considerable amount of expertise in their own field from which to draw, they still needed to integrate what they knew with the Trigger and emergent connections. Participants reported activities such as testing, further reflection, learning and research, networking, and writing abstracts, articles, reports, and books.

4.4.1.4 Valuable Outcome

There must be a positive aspect to the experience in order for it to be considered serendipitous. The *Valuable Outcome* was identified as the perceived value or impact of the experience and can be described on three main levels: A) personal, B) organizational or community, and C) global. Many described the value of their experience in reference

to how it positively affected them personally – using words and phrases such as *joy*, *intellectual pleasure*, and *satisfying personally*. Even within the personal level there was a spectrum in which the outcome ranged from substantial, life-changing personal impacts to much lower-level personal outcomes. For example, the IM professor (P12) commented that his serendipitous experience in which he stumbled upon a new way of presenting a topic to his class, "didn't change me personally, but I thought, 'okay, hey, this is interesting to present this topic'. So down the road this is how I would approach the presentation." In stark contrast, the medical doctor (P4) reflected that his serendipitous experience as a young intern had a profound and positive life-changing impact. Many of the experiences described by the participants continued to have a reverberating effect, as noted through their expressed hoped-for outcomes and their present-tense explanations of Follow-up. Some were waiting to see if there would be a Valuable Outcome beyond the initial personal satisfaction that it brought. It appeared sufficient, however, that there was at least a personal Valuable Outcome or a potential or hoped-for Valuable Outcome for there to be a perception of the experience as serendipitous.

The outcome of the experience was also perceived as valuable at the level of the individual's organization or professional, scholarly, or cultural community. The molecular biologist (P8) indicated that the Valuable Outcome was an extension of knowledge in her area of research:

> The thing is every time you discover a new organism that is not closely related to another organism with an antifreeze, then what we find is that they have totally different protein. So each new one we add to the repertoire sort of expands our knowledge of how proteins can interact with ice and change it.

Finding the insects hopping on the snow while skiing led to another piece being added to the puzzle with respect to antifreeze proteins – a significant contribution to the field.

One participant perceived that her experience generated global awareness of everyday injustice. The occupational therapy scholar's (P5a) insights, her new way of conceptualizing occupational therapy in relation to justice, sparked an interest in the everyday concept of "occupational justice." This raised awareness amongst those interested in occupational justice and has helped to forge justice and human rights

discussions with philosophers, educators, and policy makers on the world stage. She remarked that "this insight hasn't changed the world drastically but it has, it has had what you might call a wedge effect." The global outcome of her experience did not surface immediately but rather it took a long period of time and was continuing to take effect.

4.4.1.5 Unexpected Thread

Participants used words and phrases such as *just happened to, surprising, blew my mind, accident*, *chance, random, unusual,* and *unexpected* to describe the Trigger, Connection, Follow-up, or Valuable Outcome. And sometimes unexpected was threaded through the narrative of serendipity, touching more than one of these elements. The occupational therapy professor (P3), for example, noted that after realizing the unexpected Connection between her research and others, she worked with them to get it published. This collaboration – integral to Follow-Up – was also unexpected:

> You don't usually work that way. You don't usually work from combining three different studies and coming up with something. That is really, really unusual in this field. You usually go off in your corner and write your little thing. So I thought that was pretty exciting.

While Unexpected Thread is critical to serendipity, it also underlies the subjectivity of the experience and raises an important question: does the unexpected aspect have to be perceived by the person experiencing serendipity for it to be considered serendipity?

The molecular biologist's (P8) example was reported in the media as serendipitous due to the manner in which she stumbled upon the Trigger (insects hopping on the snow) – while skiing. Her own perception of the experience, however, was different – she had not thought of it as particularly serendipitous, particularly in the context of other serendipitous discoveries in science such as X-rays. As well, she reported that she periodically goes outside with her lab to collect specimens to be tested in the lab – "the only flaky thing about it was the time that I happened to notice these particular creatures was when I was skiing. They just happened to be abundant at that particular time and that's it." This illustrates that there are degrees of serendipity that hinge upon the element of unexpectedness in the eye of beholder.

4.4.1.6 Summary

There are five elements of the process of work-related serendipity including four main stages – Trigger, Connection, Follow-up, and Valuable Outcome – together with an Unexpected Thread that runs through one or more of these stages. The process is illustrated in Figure 3. The arrow reaching upward from Connection to Trigger is dotted to allow for the possibility that there may be multiple echoes of a Trigger in different forms should the Connection between initial Trigger and one's knowledge and experience or the relevance of that Trigger be delayed. The Follow-up element in Figure 3 is faded to represent the notion that the perception of a Valuable Outcome may be perceived before Follow-up occurs. The fifth element, Unexpected Thread, is unique in that it does not exist on its own; rather, the unexpected is coupled with one or more of the other elements and is crucial to the perception of the experience as serendipitous.

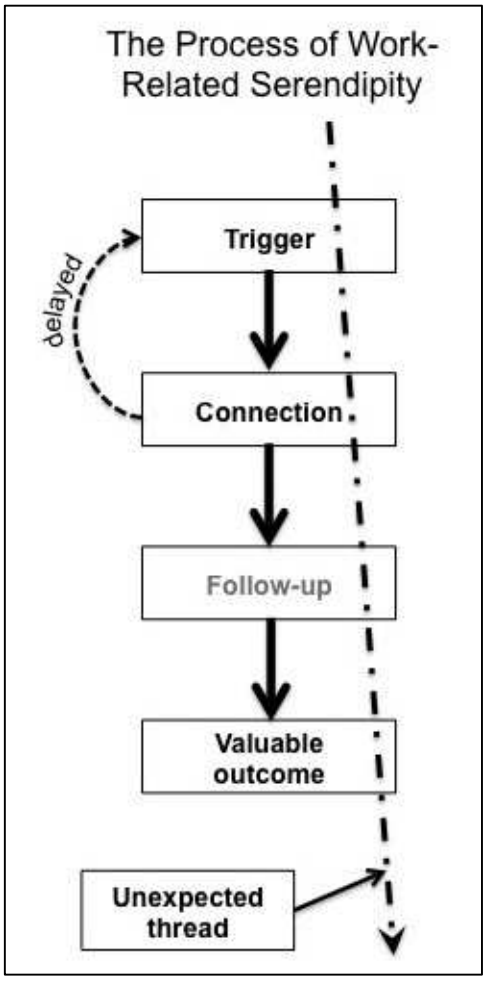

Figure 3 The process of work-related serendipity

4.4.2 What Influences Serendipity

The preceding section described the main elements of the process of serendipity. But what might influence this process? The participants' perceptions of serendipity were used to identify what may have influenced the process of serendipity – perceptions relating to, for example, emotions, motivations, pressures, capabilities, and experiences as well as their perceptions of features or characteristics of the systemic context (e.g., information objects, functionalities of interfaces) and organizational-social-cultural context (e.g., work-related interests, colleagues) (Ingwersen & Järvelin, 2005, p. 279). These perceptions are divided into two main groups: 1) those relating to the self or individual and 2) those relating to the individual's environment.

4.4.2.1 The Individual

Participants described themselves as they recounted their serendipitous experiences. Four salient characteristics, states, or abilities were identified: 1) prepared mind, 2) ability to make connections, 3) unfocussed attention, and 4) openness. These four main qualities are summarized in Table 5 together with the element(s) of serendipity they appear to facilitate and are subsequently explored.

Table 5 Characteristics, states, and abilities of the individual that may influence the process of serendipity

Characteristic, state or ability	**Definition**	**Element of serendipity facilitated**	
Prepared mind	The individual's knowledge and experience.	Trigger, Connection, Follow-up	Unexpected Thread
Unfocussed attention	A temporary state in which an individual's attention is not directed toward a specific goal.	Trigger	
Ability to make connections	To be able to think critically or creatively about relationships between encountered ideas, information, and phenomena and the individual's own knowledge and experience.	Connection, Follow-up	
Openness	To be open to experience, curious, receptive, and have a relaxed nature.	Trigger, Connection, Follow-up	

Other qualities of the individual were identified in the analysis including various motivations (intrinsic and extrinsic) and emotions (positive and negative); however, no strong patterns were identified.

Prepared Mind

Most apparent is the importance of individuals' knowledge and experience in enabling serendipity – what many participants indicated as experience in their field, preparation, knowledge, and the *prepared mind* (Pasteur, see Liestman, 1992, p. 530). While the Connection component of serendipity is defined as the recognition of a relationship between the Trigger and the individual's knowledge and experience, the prepared mind is the necessary *precondition* for this stage in the process of serendipity. The prepared mind primes individuals to recognize a Trigger relative to their work and allows them to make further connections. The importance of *experience* is evident in the creative writer's explanation for why she took special note of the graffiti that was to become the inspiration for her first work of fiction:

> […] as a writer *I am really aware of text and how it sounds*. A lot of writers I talk to, especially poets, who are much more into language, are always looking for word combinations […] So text is really important to me, as it is my tool as a writer. And so found text is always just exciting. (P9, creative writer)

Her experience prepared her; when she saw the graffiti on the overpass, she recognized its potential value as a source of inspiration for her own writing – *a tool* – just as other creative writers and poets do. She had the experience to know what could be of value relative to her work.

Prepared mind also refers to how the participants' *knowledge* influenced serendipity. This is evident in the English literary scholar's (P6) description of why she was able to make a Connection where no one else had:

> So at the time because I had had *that background preparation*, I was then able to make connections and see patterns that just simply, you know, the magnitude had never been... If anybody had ever looked at it before they'd just probably seen it as just a, 'okay this needs to be filed under whatever'. (P6, English literary scholar)

Just like Luxford's (see Introduction) ability to recognize the value of the Robin Hood marginalia, not just anyone would have been capable of recognizing the value of the poet's manuscript – a prepared mind was necessary. While Follow-up for participants often involved further knowledge acquisition, they also drew heavily on their prior knowledge and experience to reach a Valuable Outcome.

Unfocussed Attention

The specific activities that participants were performing when they perceived a Trigger varied significantly – skiing, searching the web, taking a break, having a conversation, etc.; however, a notable theme, *unfocused attention*, was identified across several examples. Participants described situations in which their attention was not directed and their behaviour more was exploratory. Some participants noted shifting their attention just prior to the Trigger stage because they needed to take a mental break from what they were doing. The digital humanities scholar (P1) described how she habitually takes a mental break, as she did when she stumbled upon her Trigger:

> When I'm working, I am aware that I, I've been aware for a long time that I can probably *really* focus on something for about 55 minutes. And then I take a mental break. And the mental break might just be 60 seconds, but it's a mental break.

It was during this temporary, unfocussed state of attention, letting their minds wander, that some participants noticed the Trigger.

Ability to Make Connections

While individuals stumble upon *potential* Triggers all the time, they are useless unless the individual is able to recognize relationships between the Trigger and their knowledge and experience. Individuals actively make a Connection by drawing on their own prepared minds, but these individuals must have the *ability* to make these Connections, to think critically or creatively about potential relationships.

A number of the participants specifically noted this type of ability or skill because a Connection is not always obvious.

> So, similarly, there were connections that I just didn't see before, that I had not been open to, receptive, and the links weren't there. I am not finding it in the research; I don't see water and civility being talked about in the research. *I am making that connection in a creative way.* (P7, education scholar)

For those participants in which a Connection was not easily made, creativity and the ability to think critically influenced the serendipitous experience, particularly in the Connection and Follow-up stages of serendipity. As if to underline the importance of this ability relative to serendipity, the occupational therapy scholar (P5) indicated that it was important to teach and encourage critical thinking in students as a way to encourage serendipitous learning.

Openness

Unfocused attention influences the individual's awareness of the Trigger and appears related to another theme identified in the data – openness. Openness encompasses participants' reports of being open, receptive, and having a relaxed nature. It is difficult to tell, however, whether these characteristics are situational in nature, like the state of unfocussed attention described in the preceding section, or are representative of more stable personality traits. The consciousness of being open indicates a strategy on the part of some individuals, but is this due to personality or simply a response to the current situation that may have elicited a different response under different circumstances? By remaining open, the computer science professor (11b) was able to make a connection that he may have otherwise dismissed due to his knowledge and experience. He noted the importance of his openness: "*to be able to ignore the obvious objections of saying 'no, that is just stupid,' and say, 'I have seen something like that before.'"* Students had approached the professor with a puzzling formula that the professor felt was incorrect. But had he not been open to what the students brought to him, he would not have been able to help solve a problem that had been at the back of his mind for 15 years. Openness, therefore, refers to a quality of individuals, situational or more stable in nature that makes them open to new experiences, curious about the world around them, and a willingness to,

as the medical doctor (P4) suggests, "stir the pot."

4.4.2.2 The Environment

Participants described the social and physical environments in which they experienced serendipity – the people with which they interacted, their digital and physical environments, and the types of objects and information that sparked their experience. Four features or characteristics of the systemic context – information technology, interface, and information objects – and organizational-social-cultural context (e.g., work-related interests, colleagues) (Ingwersen & Järvelin, 2005) that appeared to facilitate serendipity were identified: 1) Trigger-Rich, 2) Highlights Triggers, 3) Enables Connections, and 4) Open. These are summarized in Table 6 and explored in the following sections.

Table 6 Characteristics of the environment that may influence the process of serendipity

Characteristic	**Definition**	**Element of serendipity facilitated**	
Trigger-Rich	Contains sensory cues that have the potential to spark serendipity.	Trigger	Unexpected Thread
Highlights Triggers	Highlights, points to, or otherwise alerts an individual to triggers.	Trigger	
Enables connections	Juxtaposes information and ideas to help an individual make connections.	Connection, Follow-up	
Open	Encourages exploration, critical thinking, and the sharing of knowledge and ideas.	Trigger, Connection, Follow-Up	

Trigger-Rich

A context that is Trigger-rich is one that contains the perceptual cues that have the *potential* to spark serendipity. Many of the Triggers noted in this study sprung from interactions with other people, involving both face-to-face interactions as well as asynchronous interactions mediated by information technology. The IM professor (P12), for example, noted that the TwitterDeck application he had set up on his second computer screen allowed him "to maintain this awareness" of topics in which he was interested. He commented that TwitterDeck facilitated awareness by providing "access to this stream of thoughts and ideas from different people" who shared valuable resources they otherwise would not share.

The medical doctor (P4), noted a dynamic environment full of ideas was critical to serendipity:

> potentially if things are really on the boil, and you are really in *a dynamic environment with people who have lots of views and lots of ideas and things are happening and they have big social networks* etc., etc., then things do often, do often happen. (P4, medical doctor)

Environments support serendipity by containing information and ideas outside individuals' core area of work or research, enabling individuals to brush up against information and ideas they may not have otherwise encountered. These Trigger-rich environments, however, cannot be too far from an individual's interest space. The molecular biologist (P8), for example, could not have stumbled upon insects with potentially important *antifreeze* proteins during a camel trekking safari in Sub-Saharan Africa.

Highlights Triggers

A Trigger may exist but an individual may not perceive it. The fact that those insects were *jumping* would have helped the microbiologist (P8) to see them. While jumping was a natural state of the microbiologist's Trigger, in many cases other people or information technology mediated individuals' interactions with Triggers, highlighting them, pointing to them, or otherwise alerting individuals to cues that have the potential to spark serendipity. In the majority of these cases, the Trigger was highlighted during face-to-face conversation. In addition, some of the Triggers appeared to be underscored further by the way they were conveyed. The occupational therapy professor (P3), for example, commented regarding her master's student's research finding: "I wonder if I would have caught it as much if I hadn't had an encounter with him [the masters student] and *he was really excited* about that finding". The Trigger, in this case, was clearly highlighted through the emotion of the student, making the Trigger perhaps more salient to the scholar.

In another example, a textual Trigger was brought to the attention of the IM scholar (P12) through an audible alert:

> most of the time, it (TwitterDeck) is running in the background *and sometimes you hear a noise, you just heard it, and that indicates a new message coming in*. So somebody from my friends on Twitter posted the message. And I may or may not turn around and look at my second monitor to read the message. Because sometimes I am busy and I don't read those messages all the time. (P12, IM professor)

The information professor, even when alerted, did not always turn his head to read the tweets and this is in part what makes TwitterDeck, with its constantly updating screen, a serendipitous environment for him; he looks at the screen a few times a day and sometimes, by chance, the system may call his attention to something relevant.

Enables Connections

Individuals must make a Connection for serendipity to occur but sometimes something in their systemic or organizational-social-cultural context helps this along. A context that enables connections is one in which individuals are exposed to juxtapositions of information and ideas that may facilitate a Connection. In the case of the digital humanities scholar (P1) who made the connection between her husband's use of software and her own work, how the Trigger was presented enabled her to make that connection, particularly in terms of "right time, right place":

> Yes […] we could use that lens to analyze this business of the fact that I knew about [software] as a concept, I knew quite a lot probably. But I hadn't applied it to me until that evening when I had my own database open and then saw [Bob]'s and yeah, so the time and place. Yes. (P1, digital humanities scholar)

While the scholar had previous knowledge of the software, she had never thought it could be applied to her own area of research until a conversation with her husband. Her work and her husband's were visually juxtaposed, their computer screens side-by-side, which helped her to make that Connection. More generally, the journalist (P10) talked about the nature of his work as conducive to serendipity, interviewing such a wide variety of people in a short space of time,

> You're interviewing a CEO and you're interviewing a drug addict at a clinic. You know, you are moving through such strange places that the

> connections which – if you just go to the same sort of places everyday, you might not see them. The more experiences you have, the more likely you are to see links and see serendipitous connections.

Juxtapositions help individuals see a Connection where relationships are not necessarily obvious. It seems that it is not just the Triggers that are important – the manner in which they emerge makes people take note of the Triggers or helps them make a Connection that they would not have otherwise made. Furthermore, a context that enables connections allows individuals to make further connections during Follow-up as they learn more and work toward implementing and disseminating their ideas and discoveries.

Open

While openness was an important characteristic of individuals experiencing serendipity, contexts that are open also appear to influence the process. Open environments encourage exploration, critical thinking, and sharing of knowledge and ideas support the Trigger, Connection, and Follow-up stages of a serendipitous experience. Open to some participants, for example, referred to their social context – their interactions with colleagues, mentors, and family – whether face-to-face or mediated through technology. When asked whether she thinks colleagues spark serendipity, the occupational therapy professor (P3) replied that she surrounds herself with good people and sometimes they ask the right questions. She qualifies this, though, underlining the importance of the individual in making the Connection:

> But I had to make the link; nobody was making it for me. Like [John] and [Jill] weren't making it for me and [Jen] wasn't making it for me. So there was a real interplay there between the social milieu and the accepting climate, but also that your brain has to be ticking. Do you require their questions to make your brain tick? I did that day; I don't know that I always. (P3, occupational therapy professor)

The interaction between the individual and her organizational-social-cultural context is evident here – the importance of an open environment but also the ability to make connections. Through the conversation with her colleague, [Jen], the occupational therapy professor was able to finally connect the dots and see a new occupational therapy concept that was present in [John]'s, [Jill]'s, and her own research. For some participants, this

open environment was particularly critical for making a Connection and for the Follow-up in which they often required the help of others.

4.4.2.3 Summary

Four characteristics, states, and abilities of the individual that have the potential to influence the process of serendipity were identified: prepared mind, unfocussed attention, openness, and ability to make connections. Four characteristics of the systemic context (e.g., information objects, functionalities of interfaces) and organization-social-cultural contexts of the individual were also identified: trigger-rich, highlights triggers, enables connections, and open. The importance of the various characteristics of the individual and their environments at different stages of the process of serendipity may vary. Some of what influences serendipity appears to be element-specific. An individual's unfocused attention while immersed in a trigger-rich context that also highlights triggers directly supports the Trigger element of serendipity – the spark of the experience. An individual's ability to make connections and being immersed in a context that enables connections directly supports the Connection and Follow-up elements of the process of serendipity. An individual's prepared mind, openness, and open environments may influence multiple elements of the process.

4.5 Discussion

This investigative study was designed to gain a holistic understanding of how work-related serendipity unfolds and what may influence it. By focusing on participants' specific and memorable examples of serendipity, a model of the process of serendipity was identified together with the most salient characteristics of the individual and the environment that may influence this process. This section first discusses the findings in relation to previous serendipity models (section 4.5.1) and then how findings relating to the process of serendipity and what influences it informed the two research phases to follow (section 4.5.2). The prior research and findings relating to the individual and the environment from this investigative study and Study 4 (Chapter 6) in which these relationships are tested will be explored in further detail in Chapter 7 (section 7.3).

4.5.1 Model of the Process of Serendipity

The examples drawn from the participants in this study varied considerably which allowed for the identification of themes across diverse domains of work and research and provided evidence for the existence of core elements of serendipity: 1) trigger, 2) connection, 3) follow-up, 4) valuable outcome, and 5) unexpected thread. Together they form the framework of the process of work-related serendipity. These elements reflect and confirm elements identified in previous models of serendipity (Cunha, 2005; Makri & Blandford, 2012a; McCay-Peet & Toms, 2010; Rubin et al., 2001; Sun et al., 2011) – noticing (trigger); connection (connection); post-connection (follow-up); unexpected, chance or accidental aspect (unexpected thread); and a positive aspect (valuable outcome) (See Table 2). The model developed in Study 1 differs in that it decouples the unexpected element from specific elements, allowing the unexpected to thread through one or more of elements of the process of serendipity, not tied to any one in particular. This reconceptualization better reflects the broader phenomenon of serendipity as expressed in the participant examples as well as prior research in which the unexpected aspect may be associated with the trigger, connection, follow-up, or valuable outcome. This section explores the model in relation to prior research.

Trigger: The trigger element identified through the interviews with professionals and academics aligns with the *act of noticing* (Rubin et al., 2011), *trigger* (McCay-Peet & Toms, 2010), and *noticing, examining* (Sun et al., 2011) elements of previous models and what have been described as *triggering items* that match a *user's interest space* (Björneborn, 2008). Making the distinction between the triggers, the act of noticing the triggers, and the relationship between the trigger and an individual's knowledge and experience allows us to critically examine what role the systemic and organizational-social-cultural contexts (Ingwersen & Järvelin, 2005) as well as the individual play in serendipity. The individual *notices* the trigger and *makes* the connection, but the individual's context may also influence serendipity – the trigger must be related to the individual's interests and needs.

Connection: The connection element of the current model is similarly identified in the concept of *prepared mind: prior concern + previous experience* (Rubin et el., 2011),

make new connection (Makri & Blandford, 2012a), *bisociation* (McCay-Peet & Toms, 2010), and *making connections* (Sun et al., 2011) in previous models. Variations of *known problem* and *new direction* connections identified in the current study appear in prior research. Known problem connection, for example, is closely aligned with *solution to a prior problem or concern* which then leads to a *fortuitous outcome* "without much effort (or any effort) on the part of the individual" (Rubin et al., 2011, n.p.). Known problem connection also roughly aligns with the *impact* of *reinforcing or strengthening the researcher's existing problem conception or solution* that was identified in open-ended interviews with 45 interdisciplinary scholars on their information seeking behaviours (Foster & Ford, 2003). *Taking research in a new direction* (Foster & Ford) and *new action plan or action taken* (Rubin et al., 2011) are conceptually related to both new direction connection and the actionable follow-up element identified in this study.

Delay: The model of the process of work-related serendipity (Figure 3) identified in this research includes a potential *delay* in the process of serendipity where the individual may perceive a trigger but may not immediately make the necessary connections to work or interests. Tangentially related to delay is the *incubation period* (McCay-Peet & Toms, 2010) and what Sun et al. (2011) refer to as *longer-term impacts* of serendipity. The incubation period and longer-term impacts both refer to a time-lag between an information encounter and when the information encountered becomes useful; however, with both incubation period and longer-term impacts, the *potential* usefulness of the information encountered is understood at the outset. In contrast, this study found instances in which that potential itself was not immediately understood and there was a delay in making a connection between the trigger and the individual's work or interest space.

Follow-up: The element of follow-up has been included in previous models of serendipity – *exploit connections* (Makri & Blandford, 2012a) and *capturing* (Erdelez, 2004). The current study brings these together under a single element that breaks down *how* follow-up is achieved by representing more immediate actions – *capturing* and *opportunity taken* – as well as those that could be folded into individuals' work processes – *preparation for application*. The concept of *opportunity taken* has been explored

through research on the impact of chance events on career development (Bright, Pryor, Wilkenfeld, & Earl, 2005). With the expectation of the concept of *exploit connection* (Makri & Blandford, 2012a) in which the value of the connection is maximized by following up on it, using it, or sharing it, preparation for application is largely absent from prior research. This type of follow-up represents the truly hard work that often goes into achieving a valuable outcome that has an impact on an organization or community. The trigger and connection stages are the beginning of a potentially serendipitous experience relative to scholarly and professional work. Individuals may stumble upon triggers and make connections to their work or interests, but they then have to decide whether or not to act upon them by predicting whether or not these connections are worth following up – projecting the potential value of the outcome (Makri & Blandford, 2012a). The previously mentioned case study of two scientists observing the same phenomenon with different outcomes provides a good illustration of the importance of follow-up in serendipity (Barber & Fox, 1958).

Valuable Outcome: The investigative study also confirms prior research (Sun et al., 2011) that found that individuals might perceive an experience as serendipitous before follow-up is complete, before there is a community or organizational outcome. The personal valuable outcome, the joy or intellectual pleasure they gain from the experience coupled with the unexpectedness of the experience, is enough for people to consider an experience serendipitous. This suggests a particularly strong relationship between the perception of serendipity and the concept of information encountering (Erdelez, 2004) that is associated with the front end of a serendipitous experience – the trigger and connection elements. The valuable outcomes of serendipity ranging from the personal, community, or organizational, and global level, highlight the scalability of the concept of serendipity. This scalability is reflected in a recent framework developed to classify *how* serendipitous an experience is based on how unexpected, how insightful the connection, and how valuable the outcome was or is anticipated to be (Makri & Blandford, 2012b).

Unexpected Thread: The unexpected thread captures the unexpected qualifiers that accompany different elements of all four previous models of serendipity (Table 2) – for example, *unexpected connections* (Sun et al., 2011) and *unanticipated outcome* (Makri &

Blandford, 2012a). The current study noted unexpectedness potentially throughout the process of serendipity, from trigger through to valuable outcome, though not consistently in all elements or across all examples. The presence of the unexpected thread throughout the process of serendipity also underlines the importance of the themes of intent and control in serendipity which was confirmed in the larger web-based study (Study 4) in which locus of control played a role in perceptions of serendipity (this will be discussed further in the following section). Unexpected thread was the most difficult element to pin down due to its variability across various examples of serendipity. But the perception of the unexpected was critical to the perception of the experience as serendipitous, however it manifested itself. In essence, the unexpected was important to the retelling of the experience as serendipitous (Makri & Blandford, 2012a; Rubin et al., 2011). The findings, however, suggest that serendipity may take on a life of its own outside the individual who experienced it. Retold, someone else may identify all of the elements of a serendipitous experience. Because some of these elements – particularly unexpected thread and valuable outcome – are subjective, different people may come to different conclusions about the serendipitousness of the experience. The question of who makes that judgment perhaps complicates the inclusion of the reframing of or reflection on experience element in serendipity models.

The model in Figure 3 is titled "The Process of *Work-Related* Serendipity" due to its development from work-related examples of serendipity, however it may be the case that this model is applicable to all types of serendipity and could simply be titled "The Process of Serendipity." Participant examples of serendipity that involved new opportunities for work and study in particular may suggest the broader applicability of this model to everyday life serendipity which do not require the more information-intensive follow-up of the majority of the participants' work-related examples of serendipity. Serendipitous experiences of finding your spouse in an unexpected manner or stumbling on a great pair of shoes where you least expect it may also be explained through this model, though more research is need to make this assertion given the parameters of this study.

4.5.2 Next Steps

Due to the qualitative nature of this study, it is not possible to draw conclusions regarding what *causes* serendipity. However, the study does point to several variables that merit testing. The study findings suggest that the perception of serendipity hinges on how unexpected the experience was given an individual's level of control relative to abilities and actions as well as the social and physical environment. This suggests that the unexpected should be included in the conceptualization of a serendipitous environment and, by extension, a serendipitous digital environment. This will be further elaborated in Chapter 5 in which a measure of the serendipitous digital environment is developed. Also deserving further attention is the influence that individual differences may have on perceptions of the unexpected; in particular, locus of control – whether an individual perceives events occur as result of personal actions versus chance and external events. The Locus of Control of Behaviour questionnaire (Craig et al., 1984) will thus be included in the web-based study in detailed in Chapter 6.

The study findings underline the importance of the trigger stage in the process of serendipity. Having unfocussed attention appears to allow the trigger to be observed, but an environment that is trigger-rich or that in some way highlights the trigger appears to help spark the process of serendipity. In order to gain a better understanding of the role of unfocussed attention in serendipity, a lab-based experimental study would be more appropriate than the web-based survey study undertaken in this thesis (Chapter 6); therefore, unfocussed attention will not be examined further in the studies to follow and instead will be saved for future research. The qualities of the environment related to triggers – trigger-rich and highlights triggers – however, will be explored in the following chapter in the context of digital environments.

The connections and follow-up stages of the process of serendipity appear to be aided by openness, the ability to make connections, and a prepared mind. While the variable of the prepared mind will be set aside for future research, the relationship between serendipity, openness, and the ability to make connections will be tested in this thesis through the inclusion of the Openness to Experience and Extraversion questionnaires (Lee & Ashton, 2004) – individual differences that encompass sociability, curiosity, receptiveness, and

creativity. Likewise, characteristics of open environments and those that enable connections will be examined further in Chapter 5.

Through participants' rich descriptions of the events surrounding their serendipitous experiences, it is possible to identify the variables that warrant further examination. It is not possible, however, to infer from the findings whether the individual differences identified in this study are stable personality traits or whether they reflect a temporary or situational confluence. Therefore, while openness to experience and extraversion will be tested in the final web-based study, the characteristics of openness and ability to make connections, like unfocussed attention, may be situational in nature and not reflective of more stable personality traits. Future research may explore these situational factors. Furthermore, the findings represent work-related serendipity in general – not specifically digital environments, therefore the next phase will examine the model of the process of serendipity and what facilitates it through a digital lens. The next phase will focus on the development of measures of both the serendipitous digital environment and serendipity. These measures can then be used to validate and test the model developed in the first phase and integrate perceptions of serendipity and perceptions of the digital environment into the cognitive IIS&R framework (Ingwersen & Järvelin, 2005).

CHAPTER 5. MEASURING THE SERENDIPITOUS DIGITAL ENVIRONMENT (STUDIES 2 & 3) AND SERENDIPITY

5.1 OVERVIEW

Phase 1 of the research, which included a review of prior research (Chapter 2) and an investigation of serendipity (Study 1, Chapter 4), concluded that serendipity is an experience with a discernible underlying process that is potentially influenced by a number of factors. This chapter reports on the second phase of the research in which a preliminary scalar questionnaire to measure how well a digital environment supports serendipity was developed as well as a questionnaire to measure serendipity (see Figure 4). These questionnaires will be employed in the final phase to test what environmental and individual factors influence serendipity.

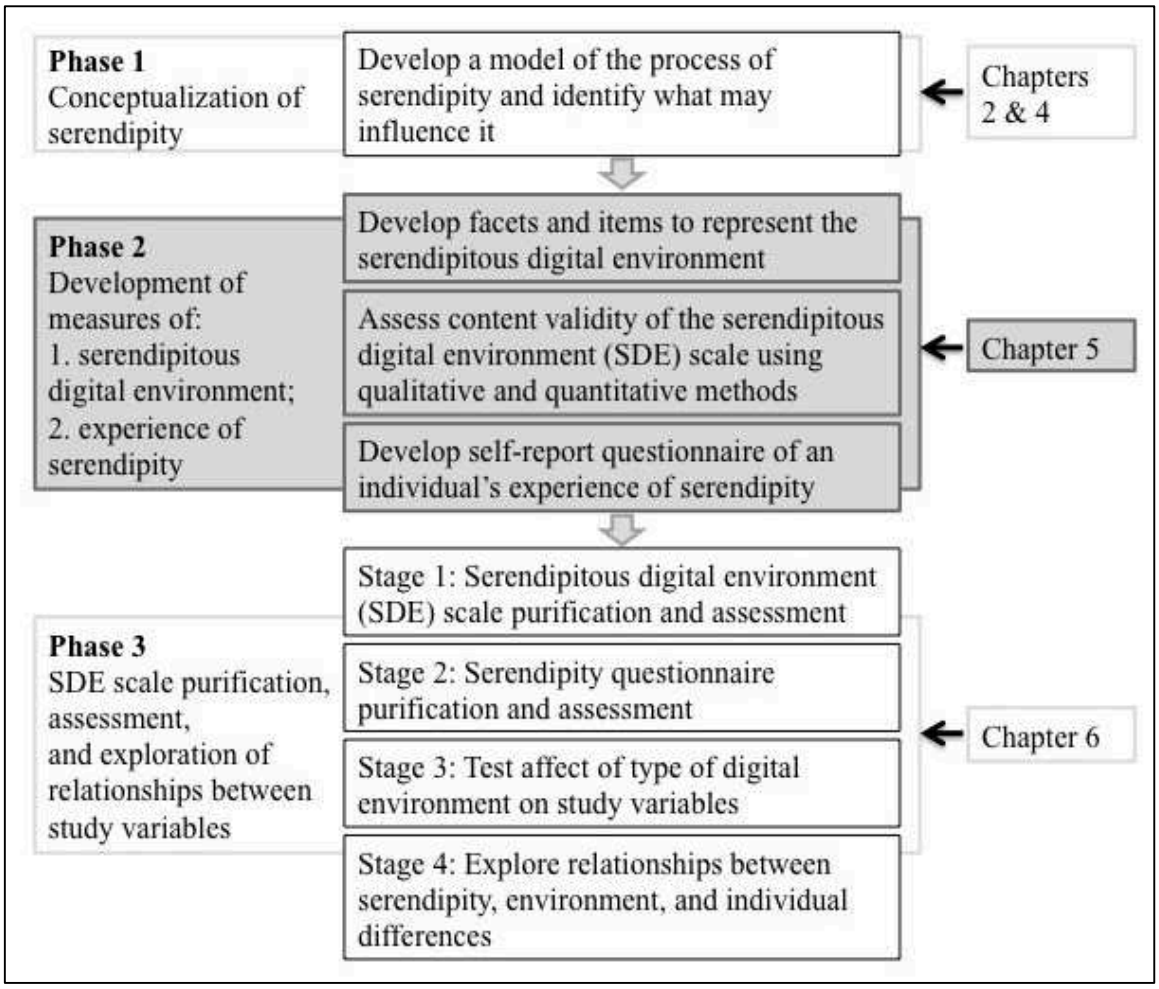

Figure 4 Current Chapter 5 in relation to study design

As DeVellis notes, one item may not be sufficient to capture a complex phenomenon; rather, "Multiple items may capture the essence of such a variable with a degree of precision that a single item could not attain" (DeVellis, 2003, pp. 9-10). The questionnaires described in this chapter consist of multiple scalar items and were used to explore relationships between key variables of interest in the final phase of this research (Chapter 6): serendipity, facets of the serendipitous digital environment, individual differences, digital environment types, and work environment. The serendipity questionnaire was also used to test the construct validity of the SDE scale. This chapter first outlines the objectives and research questions that drove this phase of the research before describing the development of the measures of 1) the *serendipitous digital environment*, and 2) *serendipity*.

5.2 Research Question

Phase 2 was motivated by the following research question:

> ***RQ2*** *How do we measure the characteristics of a digital environment that have the potential to support serendipity? And what are these characteristics?*

5.3 Measuring the Serendipitous Digital Environment

What is evident from the preceding chapters (Chapters 2 and 4) is that serendipity is influenced by a number of factors – e.g., time pressures, individual differences, and environmental factors. An individual does not exist in a vacuum and certain environments may be *more* conducive to serendipity. But how can we measure how well a digital environment – an environment reliant on computer technology – supports serendipity? Prior research examining serendipity and related constructs used a number of methods for data collection: direct observation (e.g., Bellotti et al., 2008; Björneborn, 2008), survey questionnaires (Erdelez, 1996, 1997, 2000; Heinström, 2006; Pálsdóttir, 2010), transaction logs (André, Teevan, & Dumais, 2009; Campos, 2002; Toms, 1997), think-aloud (Björneborn, 2008; Miwa et al., 2011; Yadamsuren & Erdelez, 2010), and interviews (e.g., Erdelez, 1996, 1997; Foster & Ford, 2003; McBirnie, 2008). The cumulative findings from these varying methods are suggestive of what environmental factors may facilitate serendipity in digital environments, but they have yet to be brought together in a systematic manner and tested for reliability and validity.

Due to the subjective nature of serendipity itself, self-report measures have often been used to assess how well a digital environment supports serendipity; after all, the concepts of *unexpected* and *valuable,* so intimately related to serendipity, are usually relative to the individual. To assess how well search results, recommendations, and suggestions support serendipity, for example, questionnaires have been used to collect data on how unknown yet valuable (Campos & Figueiredo, 2002), not relevant but interesting (André, Teevan, & Dumais, 2009), interesting and novel (Toms, 1997), or how interesting but previously unknown (Murakami, Mori, & Orihara, 2008) information brought to a user's attention is. The nature of the content that the system brings to the attention of its users is an important piece in understanding how well a digital environment supports serendipity. But research indicates that support for serendipity extends beyond the information, ideas, and resources *contained* in a digital environment – support for serendipity is also related to the multitude of ways in which users may interact with that content and how content is presented. The serendipitous digital environment (SDE) scale, therefore, is grounded in the facets or features of a digital environment that I hypothesize facilitate serendipity – facets reflecting the information objects, information technologies, and interfaces of digital environments.

Five facets or features of a potentially serendipitous digital environment were identified, grounded in the conceptualizing phase of the SDE scale development process, involving a review of prior research (Chapter 2) as well as a study exploring the process of serendipity and what influences it (Chapter 4): 1) Enables Exploration, 2) Trigger-Rich, 3) Enables Connections, 4) Highlights Triggers, and 5) Leads to the Unexpected. The serendipitous digital environment takes a pivotal role in serendipity – enabling, containing, exposing, pointing to, and providing what it is that helps a person to have a serendipitous experience, though never guarantees serendipity.

The following sections describe five facets of a serendipitous *digital* environment and the statements or items that reflect how these facets were developed and refined. Two successive approaches, one qualitative and one quantitative, to assess content validity of these facets and items were conducted: 1) an "expert review" (DeVellis, 2003) of the facets and items by eight international researchers with expertise in serendipity and

related constructs; and 2) an "ANOVA approach" (Hinkin & Tracey, 1999) in which 107 university students assessed the content validity of the items in relation to the facet definitions.

5.3.1 Development of SDE Facets

The following describes the five preliminary facets of the SDE, their origins, and rationale for inclusion. Table 7 provides a summary.

1. Enables Exploration.

> *The digital environment supports the unimpeded examination of its information, ideas or resources.*

The investigative study (Study 1, Chapter 4) and prior research indicate that serendipity may be more apt to occur in an *open* environment, an environment that, for example, supports explorability and unimpeded direct access (Björneborn, 2008). And thus, through a digital lens, *open environment* has been conceptualized as a digital environment that Enables Exploration. This facet addresses the user's perception of the digital environment's interface, the mechanisms that allow users to interact with the content of the digital environment. It is hypothesized that a digital environment that the user perceives supports exploration and reduces barriers to information or resource discovery feeds the perception of the environment as conducive to serendipity.

2. Trigger-Rich.

> *The digital environment is filled with a variety of information, ideas, or resources interesting and useful to the user.*

Much of the prior research (e.g., Pálsdóttir, 2011; Sun et al., 2011) points to the importance of the nature of content to serendipity – the information, ideas, or resources with which individuals interact. This facet addresses the top-down attentional aspect of serendipity or the degree to which the informational content of a digital environment matches the interests and needs of the user. While much of the content of a digital environment may not be useful to any one user, a digital environment should be perceived to hold nuggets of valuable content. It is hypothesized that a digital environment that is Trigger-Rich will be more likely to support serendipity and thus lead to the perception of a serendipitous digital environment.

Table 7 The five proposed facets of a serendipitous digital environment and origins

Facets of a serendipitous digital environment and their characteristics	**Serendipity-related construct**	**Origin**
Enables exploration: The digital environment supports the unimpeded examination of its information, ideas or resources.		
Open	Serendipity	Study 1 (Chapter 4)
Unimpeded and direct access; Explorability; Stopability; Multi-reachability	Serendipity (divergence)	(Björneborn, 2008)
Browsable environment	Opportunistic discovery of information (ODI); information encounters	(Beheshti & Large, 2011)
Trigger-rich: The digital environment is filled with a variety of information, ideas, or resources interesting and useful to the user.		
Trigger-rich	Serendipity	Study 1 (Chapter 4)
Information intensive	Information encountering	(Erdelez, 1995)
Diversity of resources; Triggering items that match a user's interest space	Serendipity (divergence)	(Björneborn, 2008)
Exposure to variety of information	ODI; information encounters	(Beheshti & Large, 2011)
Resource-rich	Serendipity	(Sun et al., 2011)
People sharing expertise or similar interests and concerns	Information encountering	(Erdelez, 1995)
	Serendipity	(Dantonio, 2010)
	ODI	(Pálsdóttir, 2011)
	IIA	(Williamson, 1998)
Something of value to the finder	Everyday chance encounters	(Rubin et al., 2011)
Helpful in their life	Information encountering; serendipity	(Ross, 1999)
Related to interests or problems	Information encountering	(Erdelez, 1995)
	Serendipity	(Sun et al., 2011)
Useful/interesting information	ODI	(Pálsdóttir, 2011)
Useful/interesting information	Serendipity	(Campos & Figueiredo, 2002; Dantonio, 2010; Toms, 1997)
Semi-relevant suggested pages	Serendipity; Chance encounters	(Toms, 1997); (Toms & McCay-Peet, 2009)

Facets of a serendipitous digital environment and their characteristics	Serendipity-related construct	Origin
Highlights triggers: The digital environment actively points to or alerts users to interesting and useful information, ideas, or resources using visual, auditory, or tactile cues.		
Highlights triggers	Serendipity	Study 1 (Chapter 4)
Curiosity-invoking display of resources; striking contrasts; pointers	Serendipity (divergence)	(Björneborn, 2008)
Emails with links to webpages with unexpected, interesting information	Serendipity	(Campos & Figueiredo, 2002)
Enables connections: The digital environment exposes users to combinations of information, ideas, or resources that make relationships between topics apparent.		
Enables connections	Serendipity	Study 1 (Chapter 4)
Provides opportunity for creative, combinatorial play	Serendipity	(Kerne, Koh, Smith, Webb, & Dworaczyk, 2008)
Cross contacts	Serendipity (divergence)	(Björneborn, 2008)
Unexpected connection	Serendipity	(Sun et al., 2011)
Leads to the unexpected: The digital environment provides fertile ground for unanticipated or surprising interactions with information, ideas, or resources.		
Unexpected thread	Serendipity	Study 1 (Chapter 4)
Random selection	Serendipity	(Ross, 1999)
Chance	Everyday chance encounters	(Rubin et al., 2011)
Imperfections in the library	Serendipity (divergence)	(Björneborn, 2008)
Misshelved books	Serendipity when browsing	(Delgadillo & Lynch, 1999)
Unexpected connection; Unexpected finding of information; Unfamiliar environments	Serendipity	(Sun et al., 2011)
Existence or location of information is unexpected; Value of information found is unexpected	Serendipity	(Foster & Ford, 2003)
Unexpected information	Serendipity	(Campos & Figueiredo, 2002)
Unexpected encounters with social media	Serendipity	(Dantonio, 2010)

3. Highlights Triggers.

The digital environment actively points to or alerts users to interesting and useful information, ideas, or resources using visual, auditory, or tactile cues.

While Trigger-Rich refers to the content of the digital environment, the Highlights Triggers facet addresses the way in which the content of a digital environment that is useful and interesting to a user is *presented* – the bottom-up, attentional aspect. Digital environments contain vast amounts of information. Research suggests that a digital environment that brings interesting and useful content to a user's attention has the potential to support serendipity (Björneborn, 2008; Campos & Figueiredo, 2002). This may be through visual, auditory, or tactile cues, or through more subtle approaches that minimize distraction. It is hypothesized that a digital environment that Highlights Triggers will help to facilitate serendipitous experiences and thus be perceived as serendipitous.

4. Enables Connections.

The digital environment exposes users to combinations of information, ideas, or resources that make relationships between topics apparent.

Making a connection is critical to the process of serendipity and that connection may be enabled by someone or something (Study 1, Chapter 4). The Enables Connections facet addresses the way in which the informational content of a digital environment is presented to help connections to be made. It is hypothesized that providing mechanisms and tools for users to see relationships between the resources, information, and ideas contained in the digital environment will help users make the kinds of connections that are vital to a serendipitous experience.

5. Leads to the Unexpected.

The digital environment provides fertile ground for unanticipated or surprising interactions with information, ideas, or resources.

The Unexpected Thread was one of the main elements of serendipity identified in Study 1 (Chapter 4). The Unexpected Thread present in all or part of the serendipitous experience is crucial to the perception of an experience as serendipitous and thus a digital environment as potentially serendipitous. While conceptualizations of serendipity often vary, some aspect of the unexpected is contained in each, whether it is articulated as

unexpected, unanticipated, surprise, chance, accident, or luck (e.g., Foster & Ford, 2003; Ross, 1999). It is hypothesized that for a digital environment to be perceived as serendipitous it is critical that the digital environment provide opportunity for the unexpected – the perception that it Leads to the Unexpected.

The initial facet definitions above were designed to be clear and succinct with as distinct demarcations as possible between the facets to help ensure that the facets and their items are capturing the content domain of the construct that they were intended to capture (MacKenzie et al., 2011). These facet definitions, however, were later refined in response to findings in Study 2 (see section 5.3.3).

5.3.2 Development of SDE Scale Items

Once preliminary definitions of the facets and their respective conceptual spaces were mapped out, items were developed to reflect each of the five facets. The goal of this phase of scale development was to capture the depth and breadth of the construct while at the same time "minimizing the extent to which the items tap concepts outside the domain of the focal construct" (MacKenzie et al., p. 304). Because the serendipitous digital environment is a multidimensional construct (Björneborn, 2008; McCay-Peet & Toms, 2011), items must be developed for each sub-dimension. The items for the proposed five facets of the SDE were derived from a variety of sources including the findings from the investigative study (Chapter 4), review of prior research (Chapter 2), and "deduction from the theoretical definition of the construct" (MacKenzie et al., 2011, p. 304). Using the preliminary five SDE facet definitions outlined above (section 5.3.2), seven to ten items were generated for each facet (see Table 8 to Table 12 for an initial item pool). Items are short statements designed to capture the essence of each of the facets (DeVellis, 2003). Each item refers to "the digital environment." For example, "[The digital environment] is easy to explore." When administering this questionnaire, researchers will be able to replace "[The digital environment]" with the specific website, application, or information system being tested. For example, the above statement may become: "This digital library is easy to explore" or "Wikipedia is easy to explore." Several considerations were made in the development of items relating to: 1) scale length, 2) level of specificity, 3) item wording, and 4) measurement format.

1) Scale length. Ideally, the SDE scale will be relatively short to ensure that the length will not overburden respondents. The quality of the scale, however, will not be sacrificed for brevity. Non-trivial redundancy in the initial pool was built-in to ensure the nuances of the attributes of the serendipitous digital environment are captured in the scale. This non-trivial redundancy allowed for the selection of items that would do what the scale is intended to do (DeVellis, 2003) – to assess how well a digital environment supports serendipity.

2) Level of specificity. The goal of the SDE scale is to measure a specific digital environment – for example, a social media site such as Twitter, a database such as EBSCO, or a person's work intranet. Therefore, the level of specificity of the facets, and thus their corresponding items, is intentionally low to allow for its application across a broad range of digital environments that contain various content, features, and functions, and by users with a wide range of technical vocabulary. As well, the features and functions of digital environments are constantly evolving; therefore, aiming for the right level of specificity is important if the scale is to be relevant for more than a few years. For example, in the definition of Enables Exploration, "*The digital environment supports the unimpeded examination of its information, ideas, or resources,"* no mention is made of what specific features or functions may enable exploration or what type of information, ideas, or resources and this level of specificity carries through to the items. It is left to the participants to record their perception of how well the digital environment enables exploration through responses to this facet's items. For example, to respond to the Enables Exploration facet's items, the respondents may recall their effortless interactions with a word cloud that allows them to explore a website's content or, conversely, how difficult it is to explore the digital library they are assessing that has only very basic search functions.

3) Item wording. Suggestions provided by DeVellis (2003) for the wording of scalar items were followed; items were written in simple and concise single-idea statements with unambiguous meaning.

- Avoid items that assess more than one characteristic
- Avoid items with which almost everyone or almost no one is likely to agree

- Avoid complex or compound sentences
- Keep language clear, simple, and direct
- Keep items short
- Maintain positive wording for all items

4) Measurement format. The Likert scale format was selected for the development of the serendipitous digital environment scale due to its prior use in the measurement of the perception of digital environments (Brooke, 1996; O'Brien & Toms, 2010) as well as its summative nature. Its values can be added to obtain a meaningful average [strongly disagree=1; disagree=2; neither agree nor disagree=3; agree=4; strongly agree=5]. Because the points on the scale are considered to be relatively evenly spaced, the Likert scale approximates interval measurement and thus allows for the application of more types of statistical analyses than if it were to be treated as ordinal data only (Meyers, Gamst, & Guarino, 2006, p. 23). The Likert scale was originally developed as a 5-point scale, though the optimum number of response categories is still a matter of debate (Preston & Colman, 2000). A five-point scale was selected for the SDE scale because it has been shown to give similar results as 7-point and 10-point scales and it is also perceived by respondents to be quick and easy to use unlike those with a higher number of categories (Preston & Colman, 2000).

5.3.3 Expert Review: Assessing Content Validity of SDE (Study 2)

Content validity refers to the extent to which a measurement reflects the content domain it is intended to capture (DeVellis, 2003). With respect to the SDE scale, assessment of content validity includes assessing whether the five proposed facets of the serendipitous digital environment reflect the content domain of the serendipitous digital environment and whether facet items represent the content domain of each of their respective facets. A study performed using a qualitative approach to assess content validity, an "expert review" (DeVellis), is described in the follow sections.

5.3.3.1 Methodology

Ethics approval was obtained for the expert review Study 2 as well as Study 3 (section 5.3.4) and the final web-based study (Chapter 6) from Dalhousie University's Social Sciences and Humanities Research Ethics Board (2012-2628).

Participants and Recruitment

An expert review involves the assessment of a measure by experts in the content domain (DeVellis, 2003). Therefore, international researchers with expertise in the area of serendipity and related constructs in the fields of information seeking and behaviour and human-computer interaction were asked to review the facet definitions and the pool of items. Email invitations were sent to researchers (Appendix 3.1). Eight researchers participated: Paul André, Lennart Björneborn, José Campos, Nigel Ford, Jannica Heinström, Stephann Makri, Anabel Quan-Haase, and Borchuluun Yadamsuren. These researchers all consented to have their contribution acknowledged (Appendix 3.2).

The Survey Instrument

The questionnaire was designed to establish the content validity of the preliminary serendipitous digital environment (SDE) scale through an assessment of its facets and items (Appendix 3.2). Working definitions of serendipity and the serendipitous digital environment were first provided so that they could be used as a basis for assessing the facets and items. The questionnaire itself was divided into two main sections: facets and items.

Facets. Participants were asked to assess the facets, their definitions, and the rationales that were given for their inclusion. Participants were asked to comment on, for example, the appropriateness of the facet definition relative to the notion of the serendipitous digital environment; the clarity of the definition; and suggestions for improvement. They were also asked to consider the facets as a whole and comment on whether there are more (or less) than five facets and whether the facets adequately capture the abstract concept of the serendipitous digital environment.

Items. Participants were invited to assess the items that were generated for each of the facets. The rules that were followed for scale item development were provided. Participants were asked to comment on how well the items align with the facets they are meant to capture, whether they are clear, and also whether they could suggest items that would better capture the essence of the facets.

Procedure

Those responding to the call for participation were emailed a Microsoft Word document containing the consent form, an introduction to the expert review including objectives and rationale, the facets and items questionnaire, and a final question asking whether or not participants' contributions may be acknowledged. Participants were encouraged to treat the document as a working document, to make comments throughout either in the space provided, via the comment function, or using track changes. When complete, participants returned this document via email. One of the participants requested an in-person interview; this request was accommodated and the questionnaire was used as the interview protocol and I recorded responses by hand.

Data Analysis

Responses to the questionnaire were entered into Microsoft Excel spreadsheets so that the comments relating to each of the facets and sets of items could be reviewed and common suggestions and critiques noted. Particular attention was paid to similar suggestions or critiques of the facets and items made by two or more participants. While all suggestions were taken into consideration, the final decision for changes to the facets and the facet items ultimately rests with the researcher developing the scale (DeVellis, 2003). Changes were made to the facet definitions and the pool of items based on this analysis.

5.3.3.2 Results

A number of common critiques regarding both the facets and the items were raised and participants offered numerous and valuable suggestions for improvements. Many revisions were made to improve clarity of the facet definitions and items and ultimately to strengthen content validity. Responses to the main critiques are described below.

Vagueness of facet definitions and items. As previously noted, I attempted to strike the right level of specificity, developing facets and corresponding items that would allow users to record their perceptions of a spectrum of experiences within the digital environment with no explicit references to specific features or functions that would vary extensively across digital environments. One of the participants suggested the need to operationalize these facets in the future as features or functions of digital environments and test them to see whether or not they facilitate serendipity.

Almost all digital environments reflect the facets of the SDE and its items. For example, one participant pointed out that Enables Exploration could be used to describe any type of web-based system. While hyperlinked environments are particularly adept at enabling exploration, some may do a better job than others. This scale will determine *how well* users perceive digital environments enable exploration, lead to the unexpected, etc., on a 5-point scale, allowing comparisons across environments.

The features of digital environments described by the facets do not solely facilitate serendipity. Does an environment have to be Trigger-rich or Highlight Triggers, for example, to facilitate serendipity? No, not necessarily, but research suggests the five facets make environments *more likely* to provide opportunities for serendipity. This type of critique, however, gets at the heart of construct validity; that is, is the SDE scale measuring what it is intended to measure? Construct validity will be tested in Chapter 6.

Specific facet definitions should more holistically reflect a SDE. Two participants, for example, suggested adding an *unexpected* component to the facet Enables Connections to reflect the unexpected nature of the connections. However, the Leads to the Unexpected facet was designed specifically to encompass the unexpected aspect of a serendipitous digital environment recognizing the finding in Chapter 4 that the Unexpected Thread may run through one or more of the elements of the process of serendipity – not just the Connection element. While it is anticipated that there will be varying levels of correlation between the facets, a clear demarcation between the facets was sought. Study 3 (5.3.4), describes how further demarcations were made between the facets.

Subjectivity. A few of the participants pointed out the subjectivity of the facets; however, this was intentional given the goal of the scale is to measure individuals' perceptions. To ensure the intended subjectivity of the facets is clear, all five facet definitions were changed so that they now begin with "A user's assessment of the degree to which a digital environment…" This change was made to better reflect the nature of the facets, underlining that the SDE scale will measure user *perceptions,* or their subjective experience with digital environments.

Changes to the facet definitions and their corresponding items are described below. The resulting 35 items are listed in Table 8 to Table 12 together with their initial items.

Enables Exploration. The facet definition, "*The digital environment* ***supports the unimpeded examination*** *of its information, ideas, or resources"* was revised to read: "*A user's assessment of the degree to which a digital environment* ***supports exploration and examination*** *of its information, ideas, or resources.*"

Table 8 Initial and revised items of the Enables Exploration facet

Initial items	**Revised** items
[The digital environment] is easy to explore	**Retained:** [The digital environment] is easy to explore
I am free to explore in [The digital environment]	**Revised:** [The digital environment] supports exploration
[The digital environment] offers easy access to content	**Removed**
[The digital environment] supports browsing of its content	**Removed**
I can explore [The digital environment] using a variety of its features	**Removed**
I can navigate freely within [The digital environment]	**Revised:** It is easy to wander around in [The digital environment]
[The digital environment] offers multiple pathways to information	**Retained:** [The digital environment] offers multiple pathways to information
I can interact with information in [The digital environment]	**Removed**
"There are lots of ways to access information in [The digital environment]"	**Retained:** There are lots of ways to access information in [The digital environment]
	Added: There are many ways to discover information in [The digital environment]
	Added: [The digital environment] invites examination of its content

Changes were made to the original facet definition to answer the concerns raised by four of the participants about the use of the word *unimpeded*: unimpeded is a negative rather than positive descriptor, its meaning is unclear, and impediments at times prompt creativity and perhaps, by extension, serendipity. Therefore, unimpeded was simply removed. As well, *exploration* was added to the facet definition, as it was evident from the reviews that *examination* did not adequately capture this facet's intended meaning. Of

the original nine scale items developed for this facet, three were retained, two revised, four removed, and two added (Table 8).

Trigger-Rich. The facet definition, "*The digital environment **is filled with** a variety of information, ideas, or resources interesting and useful to the user"* was revised to read: *"A user's assessment of the degree to which a digital environment **contains** a variety of information, ideas, or resources that is interesting and useful to the user."*

Filled with was changed to *contains* to simplify the wording. Of the original nine scale items, three were retained, four revised, and two removed (Table 9).

Table 9 Initial and revised items of the Trigger-Rich facet

Initial items	**Revised** items
The content contained in [The digital environment] is diverse	**Retained:** The content contained in [The digital environment] is diverse
[The digital environment] is rich with ideas	**Revised:** [The digital environment] is rich with interesting ideas
[The digital environment] offers exposure to a wide variety of information	**Retained:** [The digital environment] offers exposure to a wide variety of information
[The digital environment] is information-intensive	**Removed**
There is a depth of resources in [The digital environment]	**Revised:** There is a depth of information in [The digital environment]
[The digital environment] is rich with useful information	**Revised:** [The digital environment] is full of information useful to me
[The digital environment] contadins valuable information	**Revised:** I often find information of value to me in [the digital environment]
I would describe [The digital environment] as a treasure trove of information	**Retained:** I would describe [The digital environment] as a treasure trove of information
The content I come across in [The digital environment] is often timely	**Removed**

Enables Connections. The Enables Connections facet definition was revised from "*The digital environment **exposes users to combinations** of information, ideas, or resources that make relationships between topics apparent"* to *"A user's assessment of the degree to which a digital environment **makes relationships or connections** between information, ideas, or resources apparent."*

Participants made suggestions to simplify this facet that helped to rephrase the definition. Of the original seven scale items, three were retained, two revised, two removed, and two added (Table 10).

Table 10 Initial and revised items of the Enables Connections facet

Initial items	**Revised** items
[The digital environment] enables me to make connections between ideas	**Retained:** [The digital environment] enables me to make connections between ideas
[The digital environment] makes associations between topics apparent	**Revised:** [The digital environment] makes associations between ideas obvious
[The digital environment] presents juxtapositions of topics	**Removed**
I can see connections between topics in [The digital environment]	**Retained:** I can see connections between topics in [The digital environment]
Making links between information is easy in [The digital environment]	**Removed**
It is easy to see links between topics in [The digital environment]	**Revised:** It is easy to see links between information in [The digital environment]
In [The digital environment] I see relationships between topics I had not thought of before	**Retained:** In [The digital environment] I see relationships between topics I had not thought of before
	Added: "[The digital environment helps me make useful connections between topics I had not thought of before"
	Added: [The digital environment] allows me to make insightful connections

Highlights Triggers. The Highlights Triggers facet definition was changed from "*The digital environment* ***actively points to or alerts*** *users to interesting and useful information, ideas, or resources using visual, auditory, or tactile cues"* to "*A user's assessment of the degree to which a digital environment* ***brings*** *interesting and useful information, ideas, or resources* ***to the user's attention.****"*

Participants expressed concerns that the original definition perhaps went too far – two participants indicated that the described environment sounded overwhelming and that digital environments may provide more subtle cues to captures users' attention. Therefore, to allow for latitude on what constitutes bringing something to one's attention, this facet's definition was simplified; rather than *actively points to or alerts users* to

content *using visual, auditory, or tactile cues*, it was shortened to bringing content *to the user's attention*. Of the original ten scale items, five were retained, two were revised, and three were removed (Table 11).

Table 11 Initial and revised items of the Highlights Triggers facet

Initial items	**Revised** items
[The digital environment] often points to valuable information	**Retained:** [The digital environment] often points to valuable information
[The digital environment] draws my attention to useful information	**Retained:** [The digital environment] draws my attention to useful information
[The digital environment] highlights information that interests me	**Retained:** [The digital environment] highlights information that interests me
The way that [The digital environment] presents content often draws my attention	**Revised:** The way that [The digital environment] presents content often captures my attention
[The digital environment] alerts me to information that helps me	**Retained:** [The digital environment] alerts me to information that helps me
[The digital environment] points to information I can use	**Removed**
Features of [The digital environment] catch my eye	**Retained:** Features of [The digital environment] catch my eye
[The digital environment] entices me to take a closer look at resources.	**Removed**
In [The digital environment] I am exposed to information that I would not normally pay attention to	**Revised:** In [The digital environment] exposes me to information that I would not normally pay attention to
[The digital environment] often has the content I need just when I need it	**Removed**

Leads to the Unexpected. The Leads to the Unexpected facet definition, "*The digital environment **provides fertile ground for unanticipated or surprising interactions** with information, ideas, or resources"* was revised to read, "*A user's assessment of the degree to which a digital environment **provides opportunities for unexpected interactions** with information, ideas, or resources."*

While the majority of participants offered minor suggestions regarding wording and clarification, two participants questioned whether this was an outcome more than a facet, equating it with a serendipitous encounter itself. However, unexpected is not synonymous with serendipity and just as serendipity has multiple facets, so too does a serendipitous digital environment. No one facet is able to capture what makes a digital environment

potentially serendipitous. Of the original eight scale items, three were retained, four were revised, and one was removed (Table 12).

Table 12 Initial and revised items of the Leads to the Unexpected facet

Initial items	**Revised** items
I come across unexpected content in [The digital environment]	**Revised:** I bump into unexpected content in [The digital environment]
I stumble upon the unexpected in [The digital environment]	**Revised:** I encounter the unexpected in [The digital environment]
I am often surprised by what I find in [The digital environment]	**Retained:** I am often surprised by what I find in [The digital environment]
In [The digital environment] I come across topics by chance	**Retained:** In [The digital environment] I come across topics by chance
[The digital environment] often leads me to information I am not familiar with	**Revised:** [The digital environment] often exposes me to information I am not familiar with
My interactions within [The digital environment] are often unexpectedly valuable	**Revised:** [The digital environment] often leads me to information that is unexpectedly valuable
I stumble upon information in [The digital environment]	**Retained:** I stumble upon information in [The digital environment]
I can't anticipate what will come of my interactions in [The digital environment]	**Removed**

Other Facets. Two participants suggested other possible facets, reflecting the playfulness of a digital environment, how it stimulates curiosity, and how it supports the incubation of ideas. A separate facet for playfulness, however, would likely overlap with the discovery and exploration elements of the Enable Connections and Enables Exploration facets. Conceptually, stimulating curiosity could be encompassed within the Highlights Triggers and Trigger-Rich facets as both have the potential to stimulate curiosity. While support for the incubation of ideas could be manifested in functions that allow users to save items in personal folders and mark items as favorites to create a trail back to these items once they become useful, or set up reminders to revisit a resource, potential facet definitions and items did not adequately reflect a *serendipitous* digital environment. Potential definitions and items for a support for incubation facet appear utilitarian in nature and more conceptually related to usability and personal information management (PIM) than serendipity.

5.3.3.3 Summary

While all five facets of the preliminary SDE scale were retained and none added, the facet definitions were refined based on input from the participants. Of the 43 original items, seventeen were retained, fourteen changed, four added, and twelve removed, leaving a total of seven items per facet. The item pools for each of the facets were adjusted to clarify specific items, reduce redundancy, and to ensure that the items together represent the content domain of their respective facets. Participants' suggestions point to future research relative to serendipity including the relationship between serendipitous digital environments and personal information management as well as the need to operationalize the facets as features or functions of digital environments to test whether they do indeed facilitate serendipity. Steps toward the latter will be taken in Chapter 6.

5.3.4 Analysis of Variance Approach to Content Validation: SDE Scale (Study 3)

To further assess the scalar items, an analysis of variance (ANOVA) approach to content validation was used. Hinkin and Tracey (1999) developed this "ANOVA approach" to reduce the subjectivity of the item inclusion decision-making process. It provides a quantitative, and presumable less subjective, means of testing the strength of the relationship between an item and the facet that it is posited to reflect. This approach helps identify items that may be conceptually confounded, reflecting more than one facet, or simply suggest possible correlations between facets. This method has been used by Yao, Wu, and Wang (2008) and is recommended by MacKenzie et al. (2011).

5.3.4.1 Methodology

With the ANOVA approach method (Hinkin & Tracey, 1999), researchers ask participants to rate the extent to which items match the facet definitions on a scale of 1 (not at all) to 5 (completely). Hinkin and Tracey suggest that those items meeting two criteria of content validity be retained for further testing:

1) Items that have the highest mean rating on their posited facet; and

2) Items that have a significantly higher mean rating ($p < .05$) on their posited facet.

While these two criteria were applied in the current study, this method was also used to examine the facets and items and further revise and hone the items that did not meet these criteria in preparation for the SDE scale assessment in Chapter 6.

Participants and Recruitment

University students were recruited via social media sites including Twitter and Facebook, university student email lists, and notices on campus bulletin boards (Appendix 4.1). Students are capable of this type of cognitive task (Hinkin & Tracey, 1999) and prior research indicates that results using the ANOVA approach are consistent across adult and student samples (Yao et al., 2008). Moreover, using the student population helped to prevent exhausting the target participant pool before the next planned study that required a significant number of graduate students conducting thesis work, academics, and professionals to pre-test the SDE scale (Chapter 6).

Hinkin and Tracey (1999) suggest that 50 participants are sufficient for this type of study. Therefore, because the survey was split across two groups due to the length of the survey, the goal for recruitment was 100 participants with 50 in each survey group. A total of 107 participants completed the web-based survey. Fifty-three participants assessed half of the scalar items (Group 1-Survey 1, *N*=26; Group 1-Survey 2, *N*=27) and 54 assessed the other half of the scalar items (Group 2-Survey 1, *N*=25; Group 2-Survey 2, *N*=29).

Prior research has found that women tend to have higher survey response rates than men (Sax, Gilmartin, & Bryant, 2003) and this was reflected in this study's demographics. Participants were predominantly female (*N*=87, 81.3%) which may introduce some gender bias in the findings. Participants were between the ages of 18 and 30 (*N*=93, 86.9%) with the most common age group of 18 to 20 (*N*=42, 39.3%). The majority were undergraduate students (*N*=61, 57%) or masters students (*N*=37, 34.6%). There were no demographic differences across or within the survey groups.

The Survey Instrument

All of the facets and items used in this study are listed in Table 13. The facet definitions and the corresponding pool of items developed in the preceding sections were adjusted for this study to suit the type of task the participants were asked to perform. The word "it" replaced "this digital environment," in both the facet definitions and the items. For example, the facet definition Enables Exploration, "*A user's assessment of the degree to which a digital environment supports exploration and examination of its information, ideas, or resources"* was shortened to "*it supports exploration and examination of its*

information, ideas, or resources." Facets such as "[This digital environment] is easy to explore" were altered to read simply "It is easy to explore." This approach was designed to remind participants to think about how well the items matched the facet definitions rather than think about their own level of agreement with the statements alone. Each facet definition was presented at the top of each page and participants were asked to rate all 17 or 18 items against each of the five facets. For example, the question for the Enables Exploration facet read: "How well do the following statements capture the *gist* or *meaning* of '*it supports exploration and examination of its information, ideas, or resources*'?" Ratings were on a scale of 1 (not at all) to 5 (completely).

Table 13 Facet definitions with their corresponding items

Enables Exploration: It supports exploration and examination of its information, ideas, or resources.
E1 It is easy to explore
E2 It supports exploration
E3 It is easy to wander around in it
E4 It offers multiple pathways to information
E5 There are lots of ways to access information in it
E6 There are many ways to discover information in it
E7 It invites examination of its content
Trigger-Rich: It contains a variety of information, ideas, or resources that are interesting and useful to the user.
T1 The content contained in it is diverse
T2 It is rich with interesting ideas
T3 It offers exposure to a wide variety of information
T4 There is a depth of information in it
T5 It is full of information useful to me
T6 I often find information of value to me in it
T7 I would describe it as a treasure trove of information
Enables connections: It makes relationships or connections between information, ideas, or resources apparent.
C1 It enables me to make connections between ideas
C2 It makes associations between ideas obvious
C3 I can see connections between topics in it
C4 It is easy to see links between information in it
C5 In it I see relationships between topics I had not thought of before
C6 It helps me to make useful connections between resources
C7 It allows me to make insightful connections

(Table continued on next page)

Highlights Triggers: It brings interesting and useful information, ideas, or resources to the user's attention.
H1 It often points to valuable information
H2 It draws my attention to useful information
H3 It highlights information that interests me
H4 The way that it presents content often captures my attention
H5 It alerts me to information that helps me
H6 Features of it catch my eye
H7 It exposes me to information that I would not normally pay attention to
Leads to the Unexpected: It provides opportunities for unexpected interactions with information, ideas, or resources.
U1 I bump into unexpected content in it
U2 I encounter the unexpected in it
U3 I am often surprised by what I find in it
U4 In it I come across topics by chance
U5 It exposes me to information I am not familiar with
U6 It leads me to information that is unexpectedly valuable
U7 I stumble upon information in it

Study Design

Previous studies (Hinkin & Tracey, 1999; Yao et al., 2008) that used the ANOVA approach had fewer facets and items to assess than the SDE scale. Therefore, to reduce the potential of participant fatigue and attrition, the 35 items of the SDE scale were divided with 17 items in Survey 1 and the remaining 18 items in Survey 2. To minimize order effects, each survey group contained two surveys in which the facets were presented in a different order (Table 14).

Table 14 Survey design of the "ANOVA Approach" web-based study

Survey	Facet order	Items (randomized)
Group 1-Survey 1	E, T, C, H, U	17 items: E1-3; T1-4; C1-3; H1-4; U1-3
Group 1-Survey 2	U, C, H, E, T	17 items: E1-3; T1-4; C1-3; H1-4; U1-3
Group 2-Survey 1	E, T, C, H, U	18 items: E4-7; T5-7; C4-7; H5-7; U4-7
Group 2-Survey 2	U, C, H, E, T	18 items: E4-7; T5-7; C4-7; H5-7; U4-7

Note: E = Enables Exploration; T = Trigger-Rich; C = Enables Connections; H = Highlights Triggers; U = Leads to the Unexpected

Procedure

While Hinkin and Tracey (1999) and Yao et al. (2008) used a paper-based questionnaire, this study delivered the questionnaire via a web-based survey that was hosted on a

university server and used LimeSurvey [www.limesurvey.org], open-source survey software. The paper-based and web-based recruitment instruments gave participants the survey URL that randomly redirected them to one of the four surveys. Participants were presented with the following steps in a series of self-directed webpages:

1) Consent form briefly describing the details of participation including study incentive (chance to win one of four $50 gift card for Chapters Indigo);
2) Demographics questionnaire designed to obtain a basic profile of the respondents;
3) Introduction to the facet/item task through an example and follow-up explanation;
4) Rate 17 or 18 items based on each of the five facets;
5) Submit email address for a chance to win a gift card (optional);
6) Request a copy of the study consent form (optional);
7) Comments (optional); and
8) Thank-you for participating and an indication of when draw winners would be notified.

There were 27 pages in this web-based survey including the consent and thank-you pages. See Appendix 4.2 for consent form and study instrument details. The study ran from October 18 to November 8, 2012 and took an average of fourteen minutes to complete with a median completion time of eleven minutes.

Data analysis

Data were loaded into SPSS 17.0 statistical software and responses examined. Of the 107 data sets, seven were found to contain near-consistent item ratings of "5" or "3" suggesting perhaps these participants had not thought through their responses. However, the analysis was performed with and without these seven data sets and the results were the same, therefore all 107 data sets were retained. Repeated one-way ANOVA was conducted and pairwise comparisons were performed to test whether each item's mean rating was significantly higher on the posited facet than the other facets. Ideally, the item would score highest on the posited facet and significantly higher on that facet.

5.3.4.2 Results

Of the 35 items, 31 satisfied the first test of content validity with their highest mean ratings on their respective posited facets. The second test of content validity, that items

have a *significantly* higher rating on their posited facet, was met by 15 of the 35 items. The Enables Exploration, Enables Connections, and Leads to the Unexpected facets faired best, with the majority (four to five each) of their items' highest meaning ratings solely and significantly on their respective facets. The Trigger-Rich and Highlights Triggers facets faired very poorly on the second test of content validity with only one satisfactory item each. The results of this analysis are first summarized in Table 15 and then described in the sections to follow. The final column in Table 15 – "Highest facet(s)" – indicates on which facet(s) the items had their highest mean ratings. In cases where there are two or more facets indicated in this column, this indicates that the item was deemed an appropriate fit with more than one of the facets. For example, participants considered "The content contained in it is diverse" (T1) a good reflection of two of the facets:

1. T1's posited facet, Trigger-Rich: "It contains a variety of information, ideas, or resources that are interesting and useful to the user"; and
2. The Leads to the Unexpected facet: "It provides opportunities for unexpected interactions with information, ideas, or resources."

Conversely, when only one facet is indicated in the final column of Table 15 this indicates that the item was considered a good reflection of only one of the facets. For example, the item "It is easy to explore" (E1) was a good reflection of the posited facet of Enables exploration only: "It supports exploration and examination of its information, ideas, or resources."

Facet 1: Enables Exploration

Six of the seven items of the Enables Exploration facet had their highest mean rating on this facet. However, there were no significant differences between the ratings on this facet and other facets for three of the items. Items "It offers multiple pathways to information" (E4) and "There are lots of ways to access information in it" (E5) in particular had no significant differences across *all* five facets. In other words, similarity in meaning was found between these two items (E4, E5) and all of the facet definitions rather than Enables Exploration alone. Items E1, E2, E3, and E7, however, did exhibit adequate content validity, showing significantly higher ratings on their intended facet than the other four facets.

Facet 2: Trigger-Rich

While all of the Trigger-Rich items had the highest mean rating on this facet, only one item, "It is rich with interesting ideas" (T2) was solely highest on the posited facet. The remaining six items also rated highly on one or more of the Enables Exploration, Highlights Triggers, and Leads to the Unexpected facets.

Facet 3: Enables Connections

Again, all of the Enables Connections items had the highest mean rating on this facet. Five of the seven items were rated significantly highest on this posited facet (C1, C2, C3, C4, C7), however the remaining two items also rated highly on the Leads to the Unexpected facet (C5) and the Enables Exploration facet (C7).

Facet 4: Highlights Triggers

Six of the seven items had their highest mean rating on the Highlights Triggers facet. However, only one item, "The way that it presents content often captures my attention" (H4), was solely and significantly highest on its posited facet. There were no significant differences between ratings on this facet and one or more of the Enables Exploration, Trigger-Rich, and Leads to the Unexpected facets for the remaining six items.

Facet 5: Leads to the Unexpected

Finally, six of the seven Leads to the Unexpected items had their highest mean rating on this facet. The item, "It leads me to information that is unexpectedly valuable" (U6) had a higher mean rating on the Highlights Triggers facet. Four of the seven items were rated significantly highest on this posited facet (U1, U2, U3, U7), however the remaining three items also rated highly on one or more of the other facets.

Table 15 Mean appropriateness ratings of each item on the five facets of the SDE scale

Facet and items	*N*	E	T	C	H	U	F (df_1 , df_2)	Highest facet(s)
Enables Exploration								
E1 It is easy to explore	53	**3.72**	2.36	2.70	2.57	2.85	F (4,208) = 14.23**	E
E2 It supports exploration	53	**4.28**	2.64	2.89	2.62	3.34	F (4,208) = 26.86**	E
E3 It is easy to wander around in it	53	**3.60**	2.36	2.58	2.51	2.92	F (4,208) = 14.10**	E
E4 It offers multiple pathways to information	54	**3.44**	3.20	3.09	2.96	3.19	F (4,212) = 1.82	All
E5 There are lots of ways to access information in it	54	3.19	**3.30**	2.85	2.74	2.91	F (4,212) = 2.69*	All
E6 There are many ways to discover information in	54	**3.67**	3.41	2.83	3.04	3.39	F (4,212) = 6.71**	E, T, U
E7 It invites examination of its content	54	**4.30**	3.09	3.06	3.33	3.02	F (4,212) = 14.70***	E
Trigger-Rich								
T1 The content contained in it is diverse	53	2.81	**3.79**	2.81	2.94	*3.34*	F (4,208) = 9.14**	T, U
T2 It is rich with interesting ideas	53	2.72	**4.08**	2.49	3.55	3.15	F (4,208) = 24.59**	T
T3 It offers exposure to a wide variety of	53	3.62	**4.06**	2.74	3.32	3.42	F (4,208) = 12.02**	T, E
T4 There is a depth of information in it	53	3.25	**3.58**	2.64	2.94	*3.11*	F (4,208) = 6.61**	T, E, U
T5 It is full of information useful to me	54	2.94	**4.11**	2.74	3.57	2.85	F (4,212) = 15.93**	T, H
T6 I often find information of value to me in it	54	2.80	**4.20**	2.87	3.80	2.85	F (4,212) = 22.80**	T, H
T7 I would describe it as a treasure trove of information	54	3.22	**3.81**	2.74	3.35	3.00	F (4,212) = 8.35**	T, H

Note: * p < .05, **p < .001; N = number of participants; E = Enables Exploration; T = Trigger-Rich; C= Enables Connections; H = Highlights Triggers; U = Leads to the Unexpected; All = All facets (E, T, C, H, and U); Shaded values (e.g., 3.63) = item's highest mean rating(s); Bolded values (e.g., **4.30**) = item's highest mean score across the facets

(Table continues on next page)

Facet and items	*N*	E	T	C	H	U	*F* (df_1 , df_2)	Highest facet(s)
Enables Connections								
C1 It enables me to make connections between ideas	53	3.09	2.60	**4.30**	2.36	3.30	*F* (4,208) = 27.74**	C
C2 It makes associations between ideas obvious	53	2.64	2.55	**4.40**	2.38	2.72	*F* (4,208) = 33.52**	C
C3 I can see connections between topics in it	53	2.74	2.45	**4.36**	2.34	3.06	*F* (4,208) = 31.16**	C
C4 It is easy to see links between information in it	54	3.28	2.89	**4.28**	2.89	2.81	*F* (4,212) = 16.60**	C
C5 In it I see relationships between topics I had not thought of before	54	3.56	3.20	**4.13**	3.02	3.61	*F* (4,212) = 9.36**	C, U
C6 It helps me to make useful connections between resources	54	3.52	3.22	**4.20**	3.30	3.07	*F* (4,212) = 10.21**	C
C7 It allows me to make insightful connections	54	3.48	3.22	**4.02**	3.13	3.15	*F* (4,212) = 7.95**	C, E
Highlights Triggers								
H1 It often points to valuable information	53	2.89	3.85	2.77	**3.92**	2.98	*F* (4,208) = 15.64**	H, T
H2 It draws my attention to useful information	53	2.96	3.81	2.77	**4.30**	3.06	*F* (4,208) = 20.96**	H, T
H3 It highlights information that interests me	53	2.58	**4.00**	2.40	3.85	2.79	*F* (4,208) = 29.72**	H, T
H4 The way that it presents content often captures my attention	53	2.77	3.36	2.77	**4.17**	2.94	*F* (4,208) = 16.29**	H
H5 It alerts me to information that helps me	54	3.02	3.63	3.02	**4.02**	2.98	*F* (4,212) = 10.19**	H, T
H6 Features of it catch my eye	54	2.70	2.87	2.41	**3.24**	2.98	*F* (4,212) = 5.67**	H, E, T, U
H7 It exposes me to information that I would not normally pay attention to	54	3.31	3.26	2.93	3.83	**3.87**	*F* (4,212) = 8.69**	H, E, U

(Table continues on next page)

Note: * p < .05, **p < .001; *N* = number of participants; E = Enables Exploration; T = Trigger-Rich; C= Enables Connections; H = Highlights Triggers; U = Leads to the Unexpected; All = All facets (E, T, C, H, and U); Shaded values (e.g., 3.63) = item's highest mean rating(s); Bolded values (e.g., **4.30**) = item's highest mean score across the facets

Facet and items	*N*	E	T	C	H	U	$F\,(df_1\,,\,df_2\,)$	Highest facet(s)
U1 I bump into unexpected content in it	53	2.74	2.66	2.38	2.98	**4.23**	*F* (4,208) = 28.87**	U
U2 I encounter the unexpected in it	53	2.72	2.72	2.30	2.92	**4.13**	*F* (4,208) = 25.15**	U
U3 I am often surprised by what I find in it	53	2.64	2.72	2.30	2.72	**4.02**	*F* (4,208) = 26.94**	U
U4 In it I come across topics by chance	54	3.04	2.85	2.43	2.87	**3.69**	*F* (4,212) = 10.08**	U, E
U5 It exposes me to information I am not familiar with	54	3.39	3.33	2.61	3.61	**3.81**	*F* (4,212) = 12.33**	U, E, T, H
U6 It leads me to information that is unexpectedly valuable	54	3.37	3.69	2.85	**3.96**	3.83	*F* (4,212) = 11.25**	U, E, T, H
U7 I stumble upon information in it	54	2.85	2.78	2.72	3.15	**3.80**	*F* (4,212) = 10.69**	U

Note: * p < .05, **p < .001; *N* = number of participants; E = Enables Exploration; T = Trigger-Rich; C= Enables Connections; H = Highlights Triggers; U = Leads to the Unexpected; All = All facets (E, T, C, H, and U); Shaded values (e.g., 3.63) = item's highest mean rating(s); Bolded values (e.g., **4.30**) = item's highest mean score across the facets

In summary, fifteen of the items exhibited sufficient content validity to be retained using the two criteria of highest mean rating and significance suggested by Hinkin and Tracey (1999). The majority of the items represented by three of the facets met the two criteria: Enables Exploration (4 items), Enables Connections (5 items), and Leads to the Unexpected (4 items). Two of the facets, Trigger-Rich and Highlights Triggers have only one item each that exhibited sufficient content validity to meet the two criteria. These two facets, Trigger-Rich and Highlights Triggers, together with their items are explored below to examine how facets and items may be modified to correct for their potentially confounding meanings.

Trigger-Rich is defined as a digital environment that *contains a variety of information, ideas, or resources that are interesting and useful to the user* while Highlights Trigger is defined as a digital environment that *brings interesting and useful information, ideas, or resources to the user's attention*. While the former facet was developed to capture importance of the diversity of interesting and user content within a digital environment as a way to facilitate serendipity, the latter was developed to capture the importance of the digital environment highlighting or pointing out interesting and useful information. While all five facets definitions make reference to "information, ideas, or resources," only the Trigger-Rich and Highlights Triggers facets qualify this with "interesting and useful," thus suggesting the wording may have led the participants to rate items highly on both facets. It may be that users will also have a difficult time distinguishing between environments that highlight interesting and useful content and simply contain interesting and useful content when responding to the SDE scale.

The results indicate that the Trigger-Rich items were closely associated with both the Trigger-Rich *and* Highlights Triggers facet definitions. These items include

It is full of information *useful* to me (T5);

I often find information of *value* to me in it (T6); and

I would describe it as a *treasure trove* of information (T7)

Similarly, upon examination of the Highlights Triggers items, four of these items were rated highly on *both* the Trigger-Rich *and* Highlights Triggers definitions. These include

It often points to *valuable* information (H1)

It draws my attention to *useful* information (H2)

It highlights information that *interests* me (H3)

It alerts me to information that *helps* me (H5)

These four Highlights Triggers items each contain qualifiers to the content found in the digital environment – *valuable, useful, interests me,* and *helps me*. This suggests that the Highlights Trigger definition and its items could be revised to correct for this potentially confounding effect by removing the interesting and useful aspect of the Highlights Trigger facet definition and items. However, the participants from the expert review (Study 2, section 5.3.3) underlined the importance of the subjective quality of these two facets and their respective items. While it may be the case that the Highlights Triggers facet is attempting to do too much – capturing the interesting and useful content component as well as the attention-grabbing component of a serendipitous digital environment – it may also be the case that these two facets are related though may still function as two distinct factors in future factor analyses of the scale. Rather than make a decision at this point in the scale development process, the Highlights Triggers items referencing interesting and useful were retained and others generated that do not qualify the type of content highlighted.

A further check for qualifiers led to the removal of "often" from four items (T6, H1, H4, U3). The final set of items based on results of the expert review, the analysis of variance approach, and refinement of facets and items are contained in Table 16. Once revisions were made to the items, I reviewed the item pools for each of the five facets to check that the collective items capture the essence of their respective facets. This helps ensure that the items will do what the scale is intended to do (DeVellis, 2003), to provide a means for measuring how well a digital environment enables exploration and connections, highlights triggers, is trigger-rich, and leads to the unexpected, and ultimately how well a digital environment facilitates serendipity.

Table 16 Revised SDE scale items and notes on revisions

Items	Notes on revisions
Enables Exploration: A user's assessment of the degree to which a digital environment supports exploration and examination of its information, ideas, or resources.	
E1 [The digital environment] is easy to explore.	E4 and E5, which had high mean ratings across all facets, were replaced with E8 and E9.
E2 [The digital environment] supports exploration.	
E3 It is easy to wander around in [the digital environment].	
E6 There are many ways to discover information in [the digital environment].	
E7 [The digital environment] invites examination of its content.	
E8 [The digital environment] is an instrument for discovery.	
E9 [The digital environment] is a tool for exploration	
Trigger-Rich: A user's assessment of the degree to which a digital environment contains a variety of information, ideas, or resources that is interesting and useful to the user.	
T1 The content contained in [the digital environment] is diverse.	The wording of T3 and T7 was simplified; the qualifier "often" was removed from T6
T2 [The digital environment] is rich with interesting ideas.	
T3 [The digital environment] offers a wide variety of information.	
T4 There is a depth of information in [the digital environment].	
T5 [The digital environment] is full of information useful to me.	
T6 I find information of value to me in [the digital environment].	
T7 [The digital environment] is a treasure trove of information.	
Enables Connections: A user's assessment of the degree to which a digital environment makes relationships or connections between information, ideas, or resources apparent.	
C1 [The digital environment] enables me to make connections between ideas.	C5 was retained with minor changes ("ideas" replaced "topics")
C2 [The digital environment] makes associations between ideas obvious.	
C3 I can see connections between topics in [the digital environment].	
C4 It is easy to see links between information in [the digital environment].	
C5 In [the digital environment] I see relationships between ideas that I had not thought of before.	
C6 [The digital environment] helps me to make useful connections between resources.	
C7 [The digital environment] allows me to make insightful connections.	

(Table continued on next page)

Items	Notes on revisions
Highlights Triggers: A user's assessment of the degree to which a digital environment brings interesting and useful information, ideas, or resources to the user's attention.	
H1 [The digital environment] points to valuable information.	H8, H9, H10, and H11 were created by removing the qualifiers in H1 (valuable), H2 (useful), H3 (interests me), and H5 (helps me) respectively; the qualifier "often" was removed from H1 and H4; The wording of H7 was modified – "points out" replaces "exposes me"
H2 [The digital environment] draws my attention to useful information.	
H3 [The digital environment] highlights information that interests me.	
H4 The way that [the digital environment] presents content captures my attention.	
H5 [The digital environment] alerts me to information that helps me.	
H6 Features of [the digital environment] catch my eye.	
H7 [The digital environment] points out information that I would not normally pay attention to.	
H8 [The digital environment] points to information.	
H9 [The digital environment] draws my attention to information.	
H10 [The digital environment] highlights information.	
H11 [The digital environment] alerts me to information.	
Leads to the Unexpected: A user's assessment of the degree to which a digital environment provides opportunities for unexpected interactions with information, ideas, or resources	
U1 I bump into unexpected content in [the digital environment].	The qualifier "often" was removed from U3; the original wording of U4, U5, and U6 was modified to improve clarity.
U2 I encounter the unexpected in [the digital environment].	
U3 I am surprised by what I find in [the digital environment].	
U4 I come across topics by chance in [the digital environment].	
U5 [The digital environment] exposes me to unfamiliar information.	
U6 My interactions in [the digital environment] are unexpectedly valuable.	
U7 I stumble upon information in [the digital environment].	

5.3.4.3 Summary

The analysis of variance approach to content validation (Hinkin & Tracey, 1999) offered another way to explore the content validity of the facets and items and hone the items for the next phase of the research. A level of correlation amongst the five facets is anticipated but it was difficult to tell from the current study whether the facets – Highlights Triggers and Trigger-Rich in particular – are confounded, sharing too much conceptual space, or whether they reflect the expected relationships between the facets. It is important at this phase of scale development to be cautious not to sacrifice the construct validity of the

SDE scale for content validity at the facet level therefore items were retained, modified, removed, and added to help ensure both construct validity and content validity. Moving forward, there are five facets and 37 items of the preliminary SDE scale.

5.4 Direct Measures of Serendipity

In order to assess the validity of the preliminary SDE scale developed in the preceding sections, reflective indicators (MacKenzie et al., 2011) were developed to capture the meaning of the serendipitous digital environment construct as well as more general perceptions of serendipity. A series of three sub-questionnaires were developed – global or direct measures of serendipity designed to capture how frequently serendipity occurs on three levels, the frequency of serendipity: 1) in a specific digital environment; 2) in digital environments in general; and 3) in general (no specific environment). Serendipity is not anticipated to happen every time an individual interacts with a digital environment – even one that fully fits the criteria of a serendipitous digital environment proposed in the current chapter. However, it is anticipated that repeated interactions with a digital environment would lead to perceptions about the characteristics of that environment including whether or not it is conducive to serendipity.

One approach to assess how well a digital environment supports serendipity is to simply be direct – do you have serendipitous experiences when you use this digital environment? The people that use the digital environment are in the best position to assess this, though there may still be a range of responses due to the subjective nature of serendipity. In prior research, direct measures of serendipity-related constructs have been designed to assess how frequently participants experience information encountering (Erdelez, 1995; Pálsdóttir, 2010), incidental information acquisition (IIA) (Heinström, 2006), or incidental exposure to news (Lee, 2009). Or, simply whether or not they experience incidental online news exposure (Tewksbury et al., 2001). Response options vary from open-ended (Erdelez), to Likert-type scale (Heinström; Lee; Pálsdóttir), to yes or no (Tewksbury) (see Table 17). The questions also vary depending on the intent of the research. While some focus on the particular type of information encountered including news (Lee; Tewksbury) and health and lifestyle (Pálsdóttir), others are broader, specifying *useful* information (Erdelez; Heinström). The questions also differ by where

the experience occurs or type of resources – some are related specifically to the internet (Lee; Tewksbury), another specifies several types of media (Pálsdóttir), while others focus on the general experience (Erdelez; Heinström).

Table 17 Global or direct measures of information encountering and incidental information acquisition in prior research

Survey question/item wording	**Responses**
Information encountering (Erdelez, 1995)	
"Describe how often and when do you usually experience bumping into useful information" (p. 161)	[Open-ended]
Incidental information acquisition (Heinström, 2006)	
"Sometimes I come across information even though I am not consciously looking for it" (p. 584) [Study A]	5-point Likert-type scale; true - false
"I have incidentally come across useful information at times when I was not looking for it" (pp. 584-585) [Study B]	4-point Likert-type scale; almost never - almost always
"Useful information can be found in unexpected contexts" (p. 585) [Study C]	4-point Likert-type scale; almost never to almost always
"I incidentally come across useful information when I am not looking for it" (p. 585) [Study C]	
"When I search information about a topic, I find information that I can use for another purpose" (p. 585) [Study C]	
Incidental exposure to news (Lee, 2009)	
"When you're on the Internet, how often do you encounter news when you were going online for a *different* purpose?" (p. 75)	Every day, 5 to 6 days per week, 3 to 4 days per week, 1 to 2 days per week, once every few weeks, less often, and never
Information encountering (Pálsdóttir, 2010)	
"Have you come across information about health and lifestyle in any of the following sources although you were not seeking the information?" (p. 231) [22 sources that included various types of media, internet and health specialists]	Five-point response scale; very often – never
Incidental online news exposure; (Tewksbury, et al., 2001)	
"When you go online, are you ever exposed to news and information on current events, public issues, or politics when you may have been going on-line for a purpose other than to get the news?" (p. 548)	Yes/No
"When you go online, do you ever encounter or come across news and information on current events, public issues, or politics when you may have been going online for a purpose other than to get the news?" (p. 548)	

None of the questions in Table 17 use the word *serendipity*, and instead describe the experience of information encountering, IIA, or incidental exposure to news in near definitional terms. For the purposes of this research, the approaches outlined in Table 17 have been incorporated into a set of questions designed to measure serendipity through items with responses on a scale, with items ranging in specificity of media or location, and including definitional items.

The twelve questions designed to be direct measures of serendipity are outlined in Table 18. The first two sets of questions use the word *serendipity* – one refers to serendipity in everyday life and the other to work-related serendipity because boundaries between work and everyday life appear to be blurred relative to serendipity. Serendipity occurs in everyday life with work-related impacts and vice versa (Study 1, Chapter 4). The third and fourth question sets take a more definitional approach, avoiding the use of the word *serendipity* in the items to help cover the broad conceptual space of serendipity and people's potentially varied conceptualizations of serendipity. The third question set mirrors Erdelez's (2005) definition of information encountering: "an instance of accidental discovery of information during an active search for some other information" (p. 180). The fourth question set was derived from Makri and Blandford's (2012a) main elements of serendipity that they identify as "a mix of *unexpectedness* and *insight* [that lead] to a *valuable, unanticipated outcome*" (p. 684). The four question sets were adapted to the three levels – specific digital environment, general digital environment, and general experience (see Table 18). The three direct measures of serendipity sub-questionnaires were used to assess the construct validity of the proposed SDE scale in the forthcoming Chapter 6. As well, the direct measures also allowed for the exploration of relationships between serendipity, individual differences, and one's work environment (see Chapter 6).

Table 18 Items to measure serendipity on three levels

Question Set	Level 1: Serendipity in a Specific DE	Level 2: Serendipity in DEs in General	Level 3: Serendipity in General
1	**[**S-SpecificDE-1] **In the digital environment I selected,** I experience serendipity that has an impact on my everyday life.	[S-DEs-1] **In digital environments** I experience serendipity that has an impact on my everyday life.	[S-Gen-1] I experience serendipity that has an impact on my everyday life.
2	[S-SpecificDE-2] **In the digital environment I selected,** I experience serendipity that has an impact on my work.	[S-DEs-2] **In digital environments** I experience serendipity that has an impact on my work.	[S-Gen-2] I experience serendipity that has an impact on my work.
3	[S-SpecificDE-3] I encounter useful information, ideas, or resources that I am not looking for **when I use the digital environment I selected.***	[S-DEs-3] I encounter useful information, ideas, or resources that I am not looking for **when I use digital environments.***	[S-Gen-3] I encounter useful information, ideas, or resources that I am not looking for.*
4	[S-SpecificDE-4**] In the digital environment I selected,** I experience mixes of unexpectedness and insight that lead to valuable, unanticipated outcomes.**	[S-DEs-4] **In digital environments** I experience mixes of unexpectedness and insight that lead to valuable, unanticipated outcomes.**	[S-Gen-4] I experience mixes of unexpectedness and insight that lead to valuable, unanticipated outcomes.**

Note: *Items adapted from Erdelez's (2005) definition of information encountering;
**Items adapted from Makri and Blandford's (2012a) elements of serendipity.

5.5 Summary

This chapter described the second phase of the research, a preparatory phase in which measures of serendipity and the SDE scale were developed. While the measures of serendipity were based on direct statements and prior definitions relating to serendipity, the SDE scale was grounded in the findings of Study 1 (Chapter 4) as well as prior research. Two studies, an expert review (Study 2, section 5.3.3) and an analysis of

variance approach to content validation (Study 3, section 5.3.4) were conducted to test the content validity of the SDE scale, to ensure that the conceptual basis for the serendipitous digital environment construct is solid, and to provide both a qualitative and quantitative means of testing, developing, and selecting items for the SDE scale.

In the end, a three-level twelve-item questionnaire measuring serendipity in a specific digital environment, in digital environments in general, and serendipity in general as well as a five-faceted, 39-item SDE scale were developed. While the direct measures will help us understand perceptions of serendipity, the SDE scale will help us understand the perceived characteristics of the digital environment that influence perceptions of serendipity. Methodologically, the development of the SDE scale described in this chapter highlights the value of using different approaches to explore the conceptual space of a fuzzy concept and assess content validity.

CHAPTER 6. SDE SCALE ASSESSMENT AND SERENDIPITY RELATIONSHIPS (STUDY 4)

6.1 Overview

This chapter reports on the final phase of the research and tests and augments findings from Phases 1 and 2 (see Figure 5). A web-based study with 289 professionals and academics was conducted consisting of a series of self-report questionnaires. The two questionnaires developed in the preceding phase (Chapter 5) – the serendipitous digital environment (SDE) scale and the serendipity questionnaire – were included in the survey as well as the Creative Environment Perceptions (Mayfield & Mayfield, 2010), Locus of Control of Behaviour (Craig et al., 1984), and Openness to Experience and Extraversion (Lee & Ashton, 2004) questionnaires.

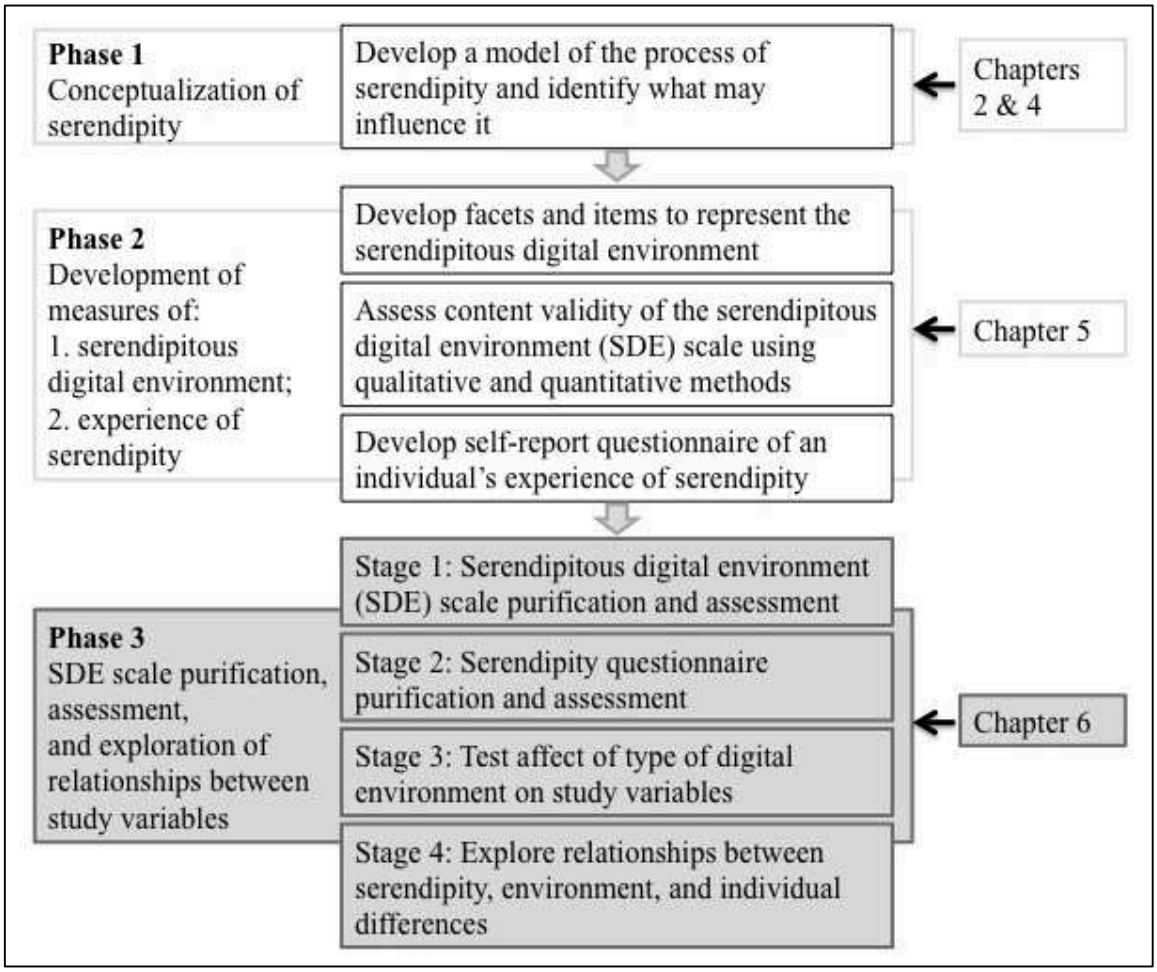

Figure 5 Current Chapter 6 in relation to study design

To help ensure an adequate amount of variance in the SDE scale responses for exploratory factor analysis (EFA), half of the participants were asked to select and assess a digital environment they use to find specific information and half were asked to assess a digital environment in which they find information they had not planned to find. The participant-selected digital environments were coded by type (website, database, search engine, social media, or intranet). EFA was used to purify the serendipity questionnaire and SDE scale and their underlying factors were computed and used as variables. Table 19 provides an overview of all study variables – their origin, definition, composition, variable type (independent vs. dependent variable), the type of data analyses in which they were employed, and the hypotheses they were used to test. Differences in the means of the eleven study variables based on type of digital environment were explored through a multivariate analysis of variance (MANOVA) while multiple regression analyses were used to examine relationships between serendipity and the study variables. Study variables are bolded throughout the rest of this chapter (e.g., **Extraversion**) to aid clarity.

Table 19 Description of variables for Study 4

Variable (origin)	**Definition**	**Composition**	**Variable type (analysis); H_n**
DE Type (Content analysis of digital environments selected by participants)	Type of digital environment	Website Intranet Database Search engine Social media	Independent variable (MANOVA); H_3, H_4
Serendipity-Specific DE (Chapters 5 & 6)	A user's perception of how frequently serendipity occurs in the specific digital environment they selected to assess.	Mean ratings of 4 items	- Dependent variable (MANOVA); H_3 - Dependent variable (multiple regression); H_5
Serendipity-DEs (Chapters 5 & 6)	A user's perception of how frequently serendipity occurs in digital environments in general.	Mean ratings of 4 items	Dependent variable (multiple regression); H_6
Serendipity-General (Chapters 5 & 6)	A user's perception of how frequently serendipity occurs in general.	Mean ratings of 3 items*	Dependent variable (multiple regression); H_7

Variable (origin)	Definition	Composition	Variable type (analysis); H_n
SDE-Enables Connections (Chapters 4, 5 & 6)	A user's assessment of the degree to which a digital environment makes relationships or connections between information, ideas, or resources apparent.	Mean ratings of 3 items*	- Dependent variables (MANOVA); H_4 - Independent variables (multiple regression); H_5
SDE-Highlights Triggers (Chapters 4, 5 & 6)	A user's assessment of the degree to which a digital environment brings interesting and useful information, ideas, or resources to the user's attention.	Mean ratings of 4 items*	
SDE-Leads to the Unexpected (Chapters 4, 5 & 6)	A user's assessment of the degree to which a digital environment provides opportunities for unexpected interactions with information, ideas, or resources	Mean ratings of 5 items*	
SDE-Trigger-Rich (Chapters 4, 5 & 6)	A user's assessment of the degree to which a digital environment contains a variety of information, ideas, or resources that is interesting and useful to the user.	Mean ratings of 3 items*	
Creative Environment Perceptions (Mayfield & Mayfield, 2010)	A person's perceptions of the level of creativity in their working environment.	Mean ratings of 9 items	Independent variable (multiple regression); H_5, H_6, H_7
Locus of Control of Behaviour (Craig et al., 1984)	The extent to which a person perceives that events are influenced by their own behaviour or, conversely, by something external to them (e.g., by chance, other people, outside actions, or events).	Mean ratings of 17 items	Independent variable (multiple regression); H_5, H_6, H_7
Openness to Experience (Lee & Ashton, 2004)	A person's perceptions of their aesthetic appreciation, inquisitiveness, creativity, and unconventionality.	Mean ratings of 16 items	Independent variable (multiple regression); H_5, H_6, H_7
Extraversion (Lee & Ashton, 2004)	A person's perceptions of their expressiveness, social boldness, sociability, and liveliness.	Mean ratings of 16 items	Independent variable (multiple regression); H_5, H_6, H_7

Note: * number of items reflects number remaining following examination of correlations (see section 6.3.5) and variable reduction using EFA (see section 6.4.1)

6.2 Hypotheses and Research Questions

One of the objectives of Phase 3 of this research was to purify the SDE scale and the serendipity questionnaire, both developed in Phase 2, and assess their reliability before using them to explore relationships between study variables. To achieve this objective, the following two hypotheses were developed to explore the possible underlying structures of the SDE scale and the serendipity questionnaire:

> ***H_1*** *The SDE is measured appropriately as a five-factor model comprised of enables exploration, trigger-rich, enables connections, highlights triggers, and leads to the unexpected.*
>
> ***H_2*** *Serendipity is measured appropriately as a three-factor model comprised of serendipity in general, serendipity in digital environments in general, and serendipity in a specific digital environment.*

While no pre-conceived structure was imposed on the outcome of the exploratory factor analyses (EFA), it was hypothesized that EFA results would indicate that the serendipitous digital environment would be best or most appropriately measured as a five-factor model comprised of the five facets described in the preceding chapter while serendipity would be appropriately as a three-factor model comprised of the three levels of serendipity described in the preceding chapter. H_1 was partially confirmed – a four-factor rather than a five-factor model emerged. H_2 was confirmed. Once I was able to measure the constructs of the serendipitous digital environment and of serendipity using variables derived from these factors, I was able to fully formulate the hypotheses that correspond with the remaining research questions. The new variables included:

- The underlying factors of the SDE scale
  - **SDE-Enables Connections**
  - **SDE-Highlights Triggers**
  - **SDE-Leads to the Unexpected**
  - **SDE-Trigger-Rich**
- The underlying factors of the serendipity questionnaire
  - **Serendipity-Specific DE**
  - **Serendipity-DEs**
  - **Serendipity-General**

My third research question refers to individuals' interactions with and perceptions of specific digital environment (e.g., my work intranet, Twitter) that they find useful in their

work. I first wanted to understand, albeit at a relatively low level of granularity, simply whether the type of digital environment it was (e.g., intranet vs. database) mattered when it came to how frequently individuals perceived serendipity occurred in it. More specifically, I also wanted to explore whether types of digital environments (**DE Type**) shared common characteristics relating to the serendipitous digital environment.

> ***RQ3*** *Does the type of digital environment in which an individual interacts influence serendipity? And are the perceived characteristics of that digital environment influenced by the type of digital environment?*

The following hypotheses were tested to answer this third research question:

H_3 DE Type *influences individual's ratings of* ***Serendipity-Specific DE****.*

H_4 *The* ***DE Type*** *influences individual's ratings of the serendipitous digital environment.*

a) ***DE Type*** *influences individual's ratings of* ***SDE-Enables Connections****.*
b) ***DE Type*** *influences individual's ratings of* ***SDE-Highlights Triggers****.*
c) ***DE Type*** *influences individual's ratings of* ***SDE-Trigger-Rich****.*
d) ***DE Type*** *influences individual's ratings of* ***SDE-Leads to the Unexpected****.*

While ***H_3*** and ***H_4*** suggest a directional relationship between **DE Type** and **Serendipity-Specific DE**, **SDE-Enables Connections**, **SDE-Highlights Triggers, SDE-Trigger-Rich**, and **SDE-Leads to the Unexpected,** both directions were treated as equally likely through a two-tailed test of significance in the analysis, a more conservative test of significance than the 1-tailed test. All eleven study variables were included in the MANOVA analysis to test the two hypotheses; however, no formal hypotheses relating to the other dependent variables (**Serendipity-DEs**, **Serendipity-General, Creative Environment Perceptions**, **Locus of Control of Behaviour**, **Openness to Experience**, and **Extraversion**) were developed as no relationships were anticipated. By performing a MANOVA and including all of the dependent variables, interrelations between the variables can be taken into account and a more complete picture of the phenomenon under scrutiny may be captured – in this case perceptions of digital environments.

Finally, I sought to address Research Question 4:

> ***RQ4*** *What relationships exist between serendipity and the underlying facets of a serendipitous digital environment, the individual's broader work environment, locus of control, openness to experience, and extraversion?*

One objective of this research question was to help validate the SDE scale by testing whether or not there is a relationship between the proposed facets of the serendipitous digital environment – how well the digital environment they selected to assess enables connections, is trigger-rich, highlights triggers, and leads to the unexpected – and how frequently individuals perceive they experience serendipity in that digital environment. The second objective was to explore relationships between serendipity, the individual's work environment, and individual differences. The following three hypotheses – each tapping a different serendipity variable (**Serendipity-Specific DE**, **Serendipity-DEs**, and **Serendipity-General**) were tested to answer this final research question:

H_5 Serendipity-Specific DE *will be positively associated with the underlying factors of a serendipitous digital environment,* ***Creative Environment Perceptions***, ***Locus of Control of Behaviour***, ***Openness to Experience***, *and* ***Extraversion***.

a) ***Serendipity-Specific DE*** *is positively associated with* ***SDE-Enables Connections***.
b) ***Serendipity-Specific DE*** *is positively associated with* ***SDE-Highlights Triggers***.
c) ***Serendipity-Specific DE*** *is positively associated with* ***SDE-Trigger-Rich***.
d) ***Serendipity-Specific DE*** *is positively associated with* ***SDE-Leads to the Unexpected***.
e) ***Serendipity-Specific DE*** *is positively associated with* ***Creative Environment Perceptions***.
f) ***Serendipity-Specific DE*** *is positively associated* ***with Locus of Control of Behaviour.***
g) ***Serendipity-Specific DE*** *is positively associated with* ***Openness to Experience***.
h) ***Serendipity-Specific DE*** *is positively associated with* ***Extraversion***.

H_6 Serendipity-DEs *will be positively associated with* ***Creative Environment Perceptions***, ***Locus of Control of Behaviour***, ***Openness to Experience***, *and* ***Extraversion***.

a) ***Serendipity-DEs*** *is positively associated with* ***Creative Environment Perceptions***.
b) ***Serendipity-DEs*** *is positively associated with* ***Locus of Control of Behaviour***.
c) ***Serendipity-DEs*** *is positively associated with* ***Openness to Experience***.
d) ***Serendipity-DEs*** *is positively associated with* ***Extraversion***.

H_7 Serendipity-General *will be positively associated with* ***Creative Environment Perceptions***, ***Locus of Control of Behaviour***, ***Openness to Experience***, *and* ***Extraversion***.

a) ***Serendipity-General*** *is positively associated with* ***Creative Environment Perceptions***.
b) ***Serendipity-General*** *is positively associated with* ***Locus of Control of Behaviour***.

c) ***Serendipity-General*** *is positively associated with* ***Openness to Experience***.
d) ***Serendipity-General*** *is positively associated with* ***Extraversion***.

It was hypothesized that individuals would perceive that serendipity occurs more frequently in serendipitous digital environments – those that enable connections, are trigger-rich, highlight triggers, and lead to the unexpected. Moreover, it was hypothesized that individuals would perceive that serendipity occurs more frequently – whether in a specific digital environment, in digital environments in general, or in general – if they work in creative environments, are more open to experience, are more extraverted, and more likely to believe that their life experiences are controlled by external events.

While H_5 includes the four factors of the serendipitous digital environment H_6 and H_7 do not as the SDE scale responses are for a specific digital environment and are not meant to extend to serendipity and serendipity in digital environments in general. However, for each of the three multiple regression analyses, all eight of the dependent variables were included for consistency and to help further validate the SDE scale.

6.3 Methodology

As previously noted, ethics approval for this study and the previous two studies was obtained from Dalhousie University's Social Sciences and Humanities Research Ethics Board (2012-2628).

6.3.1 Participants and Recruitment

Professionals and academics who frequently search for and monitor information relating to their work and graduate students conducting thesis work were invited to participate. Participants were recruited via flyers handed out at an academic conference and posted around the Dalhousie University campus through web-based forums, listservs, and social media (e.g., Facebook, Twitter), and by encouraging colleagues, PhD committee members, and participants to pass on the study link to their colleagues and graduate students (Appendix 5.1). Recruitment was conducted throughout the duration of the study (February 14, 2013 to March 18, 2013). As an incentive for participation, participants were given the opportunity to enter a draw for a chance to win one of twenty $20 Amazon gift certificates.

Participants were 289 professionals, academics, and graduate students. Participants were predominantly female (*N*= 207, 71.6%). Ages were distributed primarily within the range of 21 to 55 (*N*= 256, 88.6%), though two were between the ages of 18 and 20 (1%) and 26 (9%) were over the age of 56. Five (2%) preferred not to indicate their age. The participants were generally well educated, reporting their highest level of education as doctorate (*N*=41, 14.2%); professional degree (*N*=7, 2.4%); Master's (*N*=158, 54.7%); undergraduate (*N*=61, 21.1%); college or further education college (*N*=10, 3.5%); and high school or secondary school (*N*=9, 3.1%). Three (1%) did not indicate their level of education. The majority were employed (*N*=184, 63.7%), though many participants were (*N*=102, 35.3%) were students.

The students' (*N*=102) area of study ranged over several disciplines – most were in the social sciences (34.3%) or professions and applied sciences (29.4%), though some were in formal sciences (10.8%), humanities (7.8%), and natural sciences (4.9%). Thirteen (12.7%) students did not respond to the study area question. The employed (*N*=184) primarily indicated that the broad category of social science, education, government service, and religion (*N*=99, 53.8%) best described their area of occupation, while 11.4% (*N*=21) selected Management. Other categories such as natural and applied sciences; health; art, culture, recreation, and sport; and business, finance, and administration, each accounted for less than 5% of employees' areas of occupation. Participants (*N*=289) were generally frequent internet users. Most reported spending 1 to 2 hours per day searching for information on the internet (*N*=90, 31.1%), but others indicated 2 to 4 hours per day (*N*=109, 37.7%), and 20.4% (*N*=58) reported spending more than 4 hours per day.

Of the 289 participants, 151 (52.2%) were asked to select a particular digital environment they use in which they find specific information (Survey 1) while 138 (47.8%) were asked to select a specific digital environment in which they find information they had not planned to find (Survey 2). The two conditions were created for this study in order help ensure variance in the responses to the SDE scale to support good exploratory factor analysis. Given the criteria, not unexpectedly some differences by Survey Group were found: higher mean scores of **SDE-Trigger-Rich** were reported in Survey 1 while higher mean scores of **SDE-Leads to the Unexpected** and **Serendipity-Specific DE** were

reported in Survey 2. See Appendix 5.2 for details of this analysis.

6.3.2 Study Variables

There were twelve main study variables. Their origins, definitions, composition, type of variable (independent or dependent), and how they were analysed to test the study hypotheses are described below. See Table 19 at the beginning of this chapter for an overview of study variables.

DE Type: The type of digital environment (**DE Type**) variable was developed through content analysis of the digital environments selected by participants (see section 6.3.5). Five main types of digital environments were identified:

1. Websites
2. Databases
3. Intranets
4. Search engines
5. Social media

DE Type was used as an independent variable in multivariate analysis of variance (MANOVA) to test H_3 and H_4 – the hypotheses that **DE Type** influences how frequently serendipity occurs in a specific digital environment (**Serendipity-Specific DE**) and mean scores of the selected digital environment on **SDE-Trigger-Rich**, **SDE-Leads to the Unexpected**, **SDE-Enables Connections**, and **SDE-Highlights Triggers**.

Three serendipity variables: Serendipity is a user's perception of how frequently serendipity occurs in

1. A specific digital environment (**Serendipity-Specific DE**)
2. Digital environments in general (**Serendipity-DEs**)
3. General (**Serendipity-General**)

These three underlying factors of the serendipity questionnaire were identified through exploratory factor analysis (EFA) (see section 6.4.2). Items were originally developed in Chapter 5 (see section 5.4) as global or direct measures of serendipity designed to capture the perceived frequency of serendipity. The three new variables are comprised of the means of the three to four items of each of the three factors. Each of these three variables was used to test the hypotheses that the serendipity is positively associated with **Creative**

Environment Perceptions, **Locus of Control of Behaviour**, **Openness to Experience**, and **Extraversion** (H_5, H_6, and H_7). In addition, H_5 tested whether **Serendipity-Specific DE** is also positively associated with the underlying factors of the serendipitous digital environment (SDE) scale.

Four SDE scale variables: The underlying factors of the SDE scale were identified through EFA (see section 6.4.1) and have their origins in the investigative study (Chapter 4) as well as the content validity studies in Chapter 5. They comprise a user's assessment of the degree to which a digital environment is trigger-rich, leads to the unexpected, enables connections, and highlights triggers. The four new variables are comprised of the means of the three to five items of each of the four factors:

1. **SDE-Trigger-Rich**
2. **SDE-Leads to the Unexpected**
3. **SDE-Enables Connections**
4. **SDE-Highlights Triggers**

As previously noted, these variables were used to test H_4 and H_5.

Creative Environment Perceptions: The Creative Environment Perceptions scale (Mayfield and Mayfield, 2010) captures peoples' perceptions of the level of creativity in their working environment through responses to items such as "My supervisor encourages me to be creative" and "My organization encourages me to work creatively." The **Creative Environment Perceptions** (**CEP**) variable is comprised of the mean of responses to the nine items of this questionnaire and was used to test H_5, H_6, and H_7, as were the following three variables.

Locus of Control of Behaviour: The Locus of Control of Behaviour questionnaire (Craig et al., 1984) asks individuals to reflect on the extent to which they perceive that events are influenced by their own behaviour or, conversely, by something external to them through items such as "A great deal of what happens to me is probably just a matter of chance" and "Everyone knows that luck or chance determine one's future." The **Locus of Control of Behaviour** variable is comprised of the mean of responses to the 17 items of this questionnaire and was used to test H_5, H_6, and H_7.

Openness to Experience: Lee and Ashton's (2004) Openness to Experience questionnaire asks individuals how much they agree with statements relating to a person's perceptions of their aesthetic appreciation, inquisitiveness, creativity, and unconventionality such as "I enjoy looking at maps of different places" and "I would like a job that requires following a routine rather than being creative." The **Openness to Experience** variable is comprised of the mean of responses to the 16 items of this questionnaire and was used to test H_5, H_6, and H_7.

Extraversion: The Extraversion questionnaire (Lee & Ashton, 2004) asks individuals how much they agree with items relating to extraversion (e.g., In social situations, I'm usually the one who makes the first move; Most people are more upbeat and dynamic than I generally am). The **Extraversion** variable is comprised of the mean of responses to the 16 items of this questionnaire and was used to test H_5, H_6, and H_7.

6.3.3 The Survey Instrument

Participants were randomly assigned to one of two Survey Groups – Survey 1 in which participants were asked to select and assess a digital environment they use to find specific information or Survey 2 in which participants were asked to assess a digital environment in which they find information they had not planned to find. The only difference between the two versions was the criteria participants were given to select a digital environment to assess through the SDE scale.

The survey instrument consisted of the following components. See Appendix 5.3 for the full survey instrument.

Introduction and consent: The introductory screen described:

- The ideal participants for this study;
- The purpose of the study;
- What participants would be asked to do including study length;
- Optional incentive (chance to win an Amazon gift certificate);
- The voluntariness of the study including an explanation of the participants' right to withdraw from the study at any time;
- Efforts made to protect the anonymity and privacy of participants;
- Contact information of the researchers and the Director of Dalhousie University's Office of Human Research Ethics Administration.

Informed consent was demonstrated when participants proceeded with the survey.

Demographics: The demographics questionnaire contained multiple-choice questions relating to participants' age, gender, highest level of education, situation (student or employee), students' area of study, employee's area of occupation, and frequency of internet use. These questions were optional; that is, participants could proceed to the next page of the survey without answering these questions.

Selection of digital environment: Participants were given examples of different digital environments (your organization's intranet, a government website, ACM digital library, Twitter social media site, CNN website, Digg social news website) and then asked to indicate, using free text, one digital environment in which they either found specific information (those assigned to Survey 1) or information they had not planned to find (those assigned to Survey 2). This question was mandatory; that is, participants could not proceed to the next page of the survey without responding. Optional follow-up questions related to how often they use and how they usually access the digital environment that they selected.

SDE scale: Participants were asked to respond to the 37-item serendipitous digital environment scale developed in Chapter 5. Six to seven items were presented on each successive screen to minimize scrolling. Items were randomized to prevent order effects and responses were on a Likert scale of agreement (plus an "I don't know" option).

Serendipity questionnaire: Participants were asked to respond to the twelve items developed in Chapter 5 designed to measure serendipity on three levels: 1) serendipity in a specific digital environment, 2) serendipity in digital environments in general, and 3) serendipity in general. Within each of the three question sets, items were randomized to prevent order effects and responses were on a scale of frequency – never, rarely, sometimes, frequently, very frequently – plus an "I don't know" option.

Environment and Individual Differences questionnaires: Participants were asked to respond to a series of four questionnaires that were presented in random order. Items for each questionnaire were also randomized. Three to six items per screen were presented to minimize scrolling.

- Creative Environment Perceptions scale (Mayfield and Mayfield, 2010) included nine items with responses on a Likert scale of agreement – strongly disagree, disagree, neutral, agree, and strongly agree (plus a "not applicable" option).
- Openness to Experience questionnaire (Lee & Ashton, 2004) included 16 items with responses on a Likert scale of agreement – strongly disagree, disagree, neutral (neither agree nor disagree), agree, and strongly agree.
- Extraversion questionnaire (Lee & Ashton, 2004) included 16 items with responses on a Likert scale of agreement – strongly disagree, disagree, neutral (neither agree nor disagree), agree, and strongly agree.
- Locus of Control of Behaviour questionnaire (Craig et al., 1984) included 17 items with responses on a Likert scale of agreement – strongly agree, generally disagree, somewhat disagree, somewhat agree, generally agree, and strongly agree.

Conclusion: Participants had the option to enter the prize draw, receive recruitment notices in the future, and have a copy of the consent form emailed to them. Those responding *yes* to any of those items were asked to provide their email address. Participants were asked to comment on the survey, thanked for their participation, and encouraged to pass the survey link on to colleagues.

6.3.4 Procedure

The paper-based and web-based recruitment instruments gave participants the survey URL that randomly assigned them to one of the two surveys – one asking them to select a digital environment they use to find specific information (Survey 1) and the other asking participants to select a digital environment in which they find information they had not planned to find (Survey 2). The survey instrument was web-based, used open source LimeSurvey software (http://www.limesurvey.org), and was hosted on a secure Dalhousie University server. Participants moved through the survey in the order found above (see 6.3.3 The Survey Instrument). Participants could move forward in the survey by clicking *Next* or back by clicking *Previous*. A progress bar was visible at the top of the screen that indicated the percentage of the survey that was complete. There were 29 pages in this web-based survey including the consent and thank-you pages. Survey data, including a participant ID number, was downloaded and converted to SPSS and Microsoft Excel files

for analysis. The emails connected to responses to prize draw, consent form, and future recruitment were downloaded without a participant ID number and converted to a separate Microsoft Excel file. Random number software was used to select the 20 prize draw winners and those who requested the consent form were emailed a PDF of the form.

6.3.5 Preparation for Data Analysis

The following describes the steps taken to prepare the data and variables for analysis in SPSS 17.0. It is divided into two sections: i. The Data; and ii. The Variables.

i. The Data

Data cleaning and screening was performed in SPSS 17.0 to ensure that the data was accurate (i.e., all of the values fall within possible ranges) and was suitable for analysis (i.e., meet statistical assumptions of multivariate analyses). There were originally 353 participants; however, due to missing data and univariate and multivariate outliers, this number was reduced to 289 for data analysis after the following steps were taken.

1) Reverse scoring: Four of the questionnaires contained both negative and positive items (Creative Environment Perceptions, Openness to Experience, Extraversion, and Locus of Control of Behaviour questionnaires). These were reverse-coded.
2) Mean substitution: There were a number of missing values in the optional Creative Environment Perceptions, Openness to Experience, Extraversion, and Locus of Control of Behaviour questionnaires. All "Not applicable" responses to the Creative Environment Perceptions items were coded as discrete missing values. Means were computed for those participants who responded to at least 14 of the 16 Openness to Experience and Extraversion items, 15 of the 17 Locus of Control of Behaviour items, and seven of the nine Creative Environment Perceptions items. Those not meeting their respective thresholds were recorded as missing data.
3) Missing data: Each of the study variables contained less than 5% missing data. Tabachnick and Fidell (2013) recommend ignoring variables that contain less than 5% missing data. Due to the objectives of this study, mean substitution or other form of transformation to reduce the amount of missing data was not performed for the SDE scale data or the serendipity questionnaire data.

4) Univariate outliers: Univariate outliers for all variables were explored. Two sets of data were removed from future analysis due to careless responders (e.g., consistently recorded "1" across all items in the survey), which reduced the dataset to from *N*=353 to *N*= 351.
5) Normality and linearity: Normality and linearity were checked through an examination of skewness, kurtosis, and visual examination of the histograms, box plots, and normal QQ-plots. Variables were satisfactory.
6) Multivariate outliers: Listwise deletion reduced the dataset from *N*=351 to *N*=290. One multivariate outlier was identified through a check of Mahalanobis values. The analyses (EFA, multiple regressions, and MANOVAs) were run with and without this single participant's data. The data, however, had an influence on the results and was removed which reduced the dataset to *N*=289.

In summary, datasets were reduced from 353 to 289 due to two careless responders, one multivariate outlier, and 61 datasets with missing values that were dispersed across the 53 variables (37 SDE scale items, 12 serendipity questionnaire items, and the Openness to Experience, Extraversion, Locus of Control of Behaviour, and Creative Environment Perceptions questionnaires).

ii. The Variables

The items from the questionnaires developed in Chapter 5 – 37 the SDE scale items and the 12 serendipity questionnaire items – were explored to check correlations. To reduce the number of items in the SDE scale, exploratory factor analysis (EFA) for each of the hypothesized factors was performed and their reliability checked. Finally, the specific digital environments selected by participants were coded to prepare them for data analysis.

1) Correlations: Correlations of the 37 SDE scale items (Table 20) and the 12 serendipity questionnaire items (Table 21) were checked. Tabachnick and Fidell (2013) recommend removing a variable if there is a bivariate correlation >.70. Two items measuring serendipity in general correlated at .72:

- [S-Gen-1] I experience serendipity that has an impact on my everyday life.
- [S-Gen-2] I experience serendipity that has an impact on my work.

Because the focus of this research is on work-related serendipity, the former (S-Gen-1) was removed from further analysis. **Serendipity-General** was computed both with and without S-Gen-1 and analyses were run with both with the same results.

Table 20 Means, standard deviations, and correlations of the 37 SDE scale items

	M	SD	E1	E2	E3	E6	E7	E8	E9	T1	T2
E1	3.8	1.0	1								
E2	3.9	1.0	.51**	1							
E3	3.8	1.1	.63**	.51**	1						
E6	3.6	1.0	.42**	.38**	.34**	1					
E7	3.8	1.0	.48**	.47**	.41**	.45**	1				
E8	4.2	0.8	.41**	.61**	.37**	.33**	.43**	1			
E9	4.1	0.9	.40**	.59**	.45**	.40**	.37**	.54**	1		
T1	4.3	0.8	.14*	.28**	.14*	.29**	.26**	.38**	.30**	1	
T2	4.0	0.9	.45**	.45**	.30**	.27**	.38**	.52**	.38**	.40**	1
T3	4.4	0.7	.15*	.33**	.15*	.26**	.22**	.37**	.37**	.57**	.33**
T4	4.1	0.9	.11	.15*	.02	.28**	.15*	.18**	.20**	.19**	.17**
T5	4.3	0.8	.24**	.27**	.07	.21**	.24**	.30**	.27**	.20**	.32**
T6	4.4	0.6	.26**	.32**	.16**	.20**	.35**	.41**	.29**	.27**	.42**
T7	4.2	0.8	.35**	.40**	.24**	.31**	.34**	.42**	.43**	.27**	.42**
C1	3.6	1.0	.39**	.43**	.28**	.34**	.37**	.42**	.37**	.25**	.48**
C2	3.3	1.0	.47**	.44**	.34**	.35**	.46**	.33**	.34**	.24**	.42**
C3	3.6	1.0	.36**	.41**	.28**	.33**	.30**	.39**	.31**	.16**	.36**
C4	3.5	1.0	.43**	.43**	.31**	.36**	.46**	.33**	.38**	.16**	.35**
C6	3.7	0.9	.38**	.41**	.26**	.36**	.37**	.37**	.39**	.29**	.40**
C8	3.4	1.0	.43**	.43**	.33**	.42**	.47**	.37**	.35**	.18**	.41**
C9	3.5	1.0	.41**	.40**	.24**	.32**	.38**	.37**	.29**	.16**	.42**
H1	3.9	0.9	.39**	.46**	.33**	.36**	.41**	.47**	.39**	.28**	.44**
H2	3.5	1.0	.50**	.39**	.38**	.37**	.51**	.35**	.38**	.14*	.40**
H3	3.4	1.1	.45**	.34**	.33**	.33**	.44**	.32**	.28**	.16**	.38**
H4	3.5	1.0	.55**	.50**	.46**	.43**	.47**	.45**	.40**	.31**	.45**
H5	3.7	1.1	.39**	.35**	.35**	.34**	.39**	.35**	.35**	.21**	.30**
H7	3.8	1.0	.31**	.37**	.39**	.23**	.33**	.34**	.40**	.37**	.37**
H8	3.7	1.0	.42**	.39**	.35**	.37**	.41**	.34**	.36**	.22**	.37**
H9	3.8	1.0	.42**	.45**	.33**	.45**	.45**	.39**	.39**	.19**	.30**
H10	3.6	1.1	.39**	.33**	.27**	.36**	.47**	.32**	.30**	.18**	.33**
U1	4.0	0.9	.21**	.32**	.25**	.19**	.19**	.34**	.29**	.32**	.37**
U2	3.8	1.0	.28**	.37**	.33**	.21**	.28**	.31**	.35**	.36**	.36**
U3	3.6	1.0	.23**	.35**	.20**	.17**	.27**	.34**	.31**	.39**	.35**
U4	4.0	0.9	.18**	.32**	.24**	.20**	.15**	.29**	.43**	.26**	.28**
U5	4.0	0.9	.16**	.31**	.23**	.18**	.19**	.29**	.34**	.35**	.37**
U6	3.6	0.9	.33**	.33**	.28**	.31**	.26**	.34**	.35**	.33**	.40**
U7	4.0	0.9	.20**	.31**	.27**	.16*	.23**	.34**	.34**	.27**	.33**

Note. $N = 289$; *$p < .05$; **$p < .01$ (2-tailed)

(Table continues on next page)

	M	SD	T3	T4	T5	T6	T7	C1	C2	C3	C4
T3	4.4	0.7	1		.						
T4	4.1	0.9	.37**	1							
T5	4.3	0.8	.32**	.50**	1						
T6	4.4	0.6	.24**	.30**	.56**	1					
T7	4.2	0.8	.41**	.42**	.53**	.44**	1				
C1	3.6	1.0	.28**	.21**	.26**	.23**	.37**	1			
C2	3.3	1.0	.20**	.19**	.25**	.27**	.35**	.67**	1		
C3	3.6	1.0	.24**	.22**	.27**	.27**	.31**	.69**	.64**	1	
C4	3.5	1.0	.12*	.17**	.27**	.27**	.31**	.59**	.70**	.56**	1
C6	3.7	0.9	.24**	.14*	.24**	.26**	.36**	.53**	.43**	.47**	.46**
C8	3.4	1.0	.17**	.20**	.28**	.28**	.36**	.62**	.66**	.60**	.68**
C9	3.5	1.0	.15**	.16**	.26**	.28**	.31**	.67**	.64**	.66**	.57**
H1	3.9	0.9	.20**	.17**	.33**	.38**	.40**	.35**	.39**	.34**	.44**
H2	3.5	1.0	.08	.08	.26**	.26**	.40**	.45**	.50**	.44**	.53**
H3	3.4	1.1	.11	.10	.28**	.28**	.25**	.33**	.45**	.38**	.44**
H4	3.5	1.0	.28**	.01	.20**	.21**	.30**	.43**	.49**	.42**	.48**
H5	3.7	1.1	.14*	.08	.19**	.21**	.32**	.35**	.39**	.33**	.41**
H7	3.8	1.0	.28**	-.01	.06	.21**	.28**	.32**	.40**	.27**	.30**
H8	3.7	1.0	.19**	.01	.10	.21**	.30**	.38**	.41**	.33**	.44**
H9	3.8	1.0	.16**	.07	.20**	.25**	.32**	.35**	.43**	.35**	.46**
H10	3.6	1.1	.19**	.04	.12	.21**	.23**	.34**	.42**	.33**	.44**
U1	4.0	0.9	.29**	-.01	.10	.21**	.16**	.26**	.22**	.21**	.21**
U2	3.8	1.0	.30**	-.02	.05	.17**	.23**	.31**	.31**	.22**	.26**
U3	3.6	1.0	.25**	-.04	.08	.22**	.22**	.33**	.30**	.20**	.23**
U4	4.0	0.9	.22**	.05	.06	.20**	.15**	.25**	.22**	.21**	.22**
U5	4.0	0.9	.24**	-.01	.03	.16**	.20**	.23**	.24**	.19**	.20**
U6	3.6	0.9	.27**	.08	.18**	.26**	.30**	.42**	.36**	.33**	.34**
U7	4.0	0.9	.27**	-.02	.06	.24**	.19**	.25**	.20**	.11	.23**

Note. $N = 289$; *$p < .05$; **$p < .01$ (2-tailed)

(Table continues on next page)

	M	SD	C6	C8	C9	H1	H2	H3	H4	H5	H7
C6	3.7	0.9	1								
C8	3.4	1.0	.49**	1							
C9	3.5	1.0	.49**	.61**	1						
H1	3.9	0.9	.38**	.44**	.35**	1					
H2	3.5	1.0	.38**	.51**	.38**	.50**	1				
H3	3.4	1.1	.33**	.41**	.40**	.47**	.52**	1			
H4	3.5	1.0	.46**	.50**	.41**	.47**	.56**	.45**	1		
H5	3.7	1.1	.31**	.38**	.34**	.51**	.48**	.44**	.50**	1	
H7	3.8	1.0	.36**	.30**	.32**	.30**	.34**	.22**	.47**	.39**	1
H8	3.7	1.0	.33**	.48**	.33**	.50**	.59**	.42**	.55**	.45**	.37**
H9	3.8	1.0	.32**	.47**	.34**	.54**	.58**	.43**	.51**	.48**	.32**
H10	3.6	1.1	.32**	.43**	.32**	.46**	.56**	.44**	.55**	.55**	.32**
U1	4.0	0.9	.27**	.20**	.24**	.22**	.16**	.25**	.40**	.26**	.46**
U2	3.8	1.0	.37**	.25**	.32**	.28**	.25**	.20**	.42**	.28**	.56**
U3	3.6	1.0	.35**	.20**	.32**	.15*	.19**	.16**	.38**	.27**	.41**
U4	4.0	0.9	.35**	.18**	.26**	.17**	.18**	.22**	.31**	.25**	.50**
U5	4.0	0.9	.24**	.16**	.28**	.23**	.20**	.24**	.33**	.22**	.56**
U6	3.6	0.9	.52**	.30**	.38**	.34**	.35**	.34**	.42**	.30**	.43**
U7	4.0	0.9	.27**	.20**	.24**	.21**	.19**	.22**	.33**	.25**	.50**

	M	SD	H8	H9	H10	U1	U2	U3	U4	U5	U6
H8	3.7	1.0	1								
H9	3.8	1.0	.54**	1							
H10	3.6	1.1	.54**	.49**	1						
U1	4.0	0.9	.25**	.20**	.23**	1					
U2	3.8	1.0	.37**	.23**	.29**	.65**	1				
U3	3.6	1.0	.20**	.18**	.22**	.53**	.61**	1			
U4	4.0	0.9	.20**	.19**	.15**	.64**	.57**	.48**	1		
U5	4.0	0.9	.23**	.19**	.18**	.68**	.64**	.51**	.60**	1	
U6	3.6	0.9	.29**	.29**	.35**	.48**	.49**	.46**	.46**	.44**	1
U7	4.0	0.9	.29**	.22**	.26**	.67**	.55**	.46**	.64**	.52**	.41**

Note. $N = 289$; $^{**}p < .01$ (2-tailed)

Table 21 Means, standard deviations, and correlations of the 12 serendipity questionnaire items

		M	SD	1	2	3	4	5	6
1	S-SpecificDE-1	2.8	1.1	1					
2	S-SpecificDE-1	3.2	0.9	.57**	1				
3	S-SpecificDE-1	3.6	0.9	.43**	.53**	1			
4	S-SpecificDE-1	3.2	0.9	.53**	.63**	.60**	1		
5	S-DEs-1	3.5	0.9	.40**	.37**	.26**	.32**	1	
6	S-DEs-2	3.6	0.9	.35**	.46**	.29**	.37**	.66**	1
7	S-DEs-3	3.9	0.8	.18**	.27**	.38**	.33**	.54**	.64**
8	S-DEs-4	3.7	0.9	.28**	.37**	.35**	.48**	.64**	.70**
9	S-Gen-1	3.3	0.8	.11	.21**	.13*	.19**	.44**	.38**
10	S-Gen-2	3.3	0.8	.11	.26**	.17**	.25**	.36**	.43**
11	S-Gen-3	3.5	0.8	.00	.07	.09	.11	.19**	.27**
12	S-Gen-4	3.4	0.8	.11	.15*	.14*	.18**	.30**	.32**

		M	SD	7	8	9	10	11	12
7	S-DEs-3	3.9	0.8	1					
8	S-DEs-4	3.7	0.9	.69**	1				
9	S-Gen-1	3.3	0.8	.35**	.39**	1			
10	S-Gen-2	3.3	0.8	.33**	.36**	.72**	1		
11	S-Gen-3	3.5	0.8	.40**	.36**	.65**	.60**	1	
12	S-Gen-4	3.4	0.8	.33**	.38**	.68**	.64**	.63**	1

Note. $N = 289$. *$p < .05$; **$p < .01$

2) Preliminary reduction of SDE items and assessment of SDE subscales: The five SDE subscales were examined separately using EFA (varimax rotation) to reduce the subscales to more parsimonious sets of items. The four or five highest loading items per subscale were retained for further analysis bringing the number of items to 24.

Cronbach's alpha for each of these subscales was also calculated. DeVellis' (2003, p. 95-96) guidelines for interpreting Cronbach's alpha were followed:

< .60 = "unacceptable"
.60 – .65 = "undesirable"
.65 –. 70 = "minimally acceptable"
.70 –. 80 = "respectable"
.80 –. 90 = "very good"
>.90 "consider shortening scale"

Table 22 SDE subscales and their Cronbach's Alphas

SDE Subscale		Items	Cronbach's alpha
Enables exploration	1	E2 It supports exploration.	.84
	2	E1 It is easy to explore its content.	
	3	E9 It is a tool for exploration.	
	4	E8 It is an instrument for discovery.	
	5	E3 It is easy to wander around in it.	
Trigger-rich	6	T5 It is full of information that is useful to me.	.77
	7	T7 It is a treasure trove of information.	
	8	T6 I find information that is of value to me in it.	
	9	T2 It is rich with interesting ideas.	
Enables connections	10	C1 It enables me to make connections between ideas.	.90
	11	C2 Associations between ideas become obvious in it.	
	12	C9 I come to understand relationships between ideas in it.	
	13	C8 The features of it help me see connections between its content.	
	14	C3 I can see connections between topics in it.	
Highlights triggers	15	H2 It has features that ensure that my attention is drawn to useful information.	.85
	16	H4 The way that it presents content captures my attention.	
	17	H10 It has features that alert me to information.	
	18	H8 It has features that draw my attention to information.	
	19	H9 I am pointed toward content in it.	
Leads to the unexpected	20	U1 I bump into unexpected content in it.	.89
	21	U2 I encounter the unexpected in it.	
	22	U4 I come across content by chance in it.	
	23	U5 I am exposed to unanticipated content in it.	
	24	U7 I stumble upon information in it.	

Note. $N = 289$.

Cronbach's alphas for the subscales ranged from respectable to very good. See Table 22 above for the items retained for each of the five SDE subscales after EFA and their Cronbach's alphas.

3) Content Analysis: Finally, the free-text responses in which participants selected a specific digital environment to respond to the SDE scale were deductively coded using the following codes: databases, social media, search engines, websites, and intranets. Three more codes were inductively developed to describe the digital environments that

did not fit these categories (multiple, unclear, and other). See Table 23 for definitions and examples of each **DE Type**.

In summary, the correlations of all 53 items from the SDE scale and the serendipity questionnaire were checked. One item of the serendipity questionnaire was removed due to high correlation with another item. The original 37 items of the SDE scale developed in Chapter 5 were reduced to 24 items – four to five items per subscale. The reliability of the SDE subscales ranged from respectable to very good (DeVellis, 2003). And finally, content analysis was performed on the digital environments selected by participants to develop the **DE Type** variable. Once the SDE scale items and serendipity questionnaire items were reduced to factors and commuted to variables (forthcoming sections 6.4.1 and 6.4.2), the correlations of all study variables were explored (section 6.4.3).

Table 23 Type of digital environments selected by participants

DE Type	Examples
Databases: "a usually large collection of data organized especially for rapid search and retrieval (as by a computer)" (Database, n.d.)	"Pubmed"; "Multiple databases"; "WorldCat"; "ACM digital library"; "My universities library website"
Social media: "forms of electronic communication (as Web sites for social networking and microblogging) through which users create online communities to share information, ideas, personal messages, and other content (as videos)" (Social media, n.d.)	"Reddit"; "Google group listserv"; "Twitter"; "Moodle"; "Hootesuite"; "YouTube"; "LinkedIn; "Facebook"; "Digg"; "Quora question and answer site"
Search engines: "computer software used to search data (as text or a database) for specified information; also: a site on the World Wide Web that uses such software to locate key words in other sites" (Search engines, n.d.)	"Google"; "Google Scholar"; "Moxilla Firefox"; "search engine"
Websites: "a group of World Wide Web pages usually containing hyperlinks to each other and made available online by an individual, company, educational institution, government, or organization" (Web sites, n.d.)	"W3c.org"; "news websites"; "imbd.com"; "Government of Canada website"; "Wikipedia"; "EDUCAUSE website"; "Boing Boing Blog"
Intranets: "a network operating like the World Wide Web but having access restricted to a limited group of authorized users (as employees of a company)" (Intranets, n.d.)	"My government Intranet"; "My organization's intranet"; "Agency intranet"; "company intranet"
Multiple: A variety of digital environments rather than one or indicated a general digital environment (e.g. the web) that contains a number of types of digital environments.	"ux websites, pinterest for examples, twitter, work hard drive"; "facebook, twitter, various organizations websites"; "The Internet"; "the web generally"
Unclear: Participant response was vague, ambiguous, or indecipherable.	"Company website"; "Nng"; "1"; "HJY"; "website"
Other: The digital environment did not fit into the main types of digital environments and did not have sufficient numbers to warrant their own category.	"diigo"; "email"; "RSS Feeds (Google Reader)"

6.3.6 Data Analysis

Data analysis using SPSS 17.0 consisted of four main stages:

Stage 1: Test H_1 using exploratory factor analysis (EFA) of SDE scale (24 items).

Stage 2: Test H_2, using EFA of serendipity questionnaire (11 items).

Stage 3: Test H_3 and H_4, using a MANOVA with **DE Type** (website, database, intranet, search engine, and social media) as independent variable to explore whether differences among types of digital environments exist.

Stage 4: Test H_5, H_6, and H_7 using multiple regression analyses to identify relationships between three serendipity variables, four SDE scale variables, **Creative Environment Perceptions**, **Locus of Control of Behaviour**, **Openness to Experience**, and **Extraversion**.

These four stages are described together with the results in the following four sections.

6.4 Results

6.4.1 Stage 1: SDE Scale Purification

> ***H_1*** *The SDE is measured appropriately as a five-factor model comprised of enables exploration, trigger-rich, enables connections, highlights triggers, and leads to the unexpected.*

To explore the possible underlying five-factor structure of the SDE scale without imposing a pre-conceived structure on the outcome, exploratory factor analysis (EFA) was performed. For factor analysis, Meyers, Gamst, and Guarino (2006) recommend a sample size to number of variables ratio of ten to one, though not below *N*=200. Therefore, a sample size of 289 was adequate to proceed with data analysis as the sample size exceeds the 240 required for EFA on the 24 SDE scale items. Tabachnick and Fidell's (p. 267) suggested procedure for EFA was followed, using principal components extraction and varimax rotation before experimenting with rotation and extraction methods. Due to correlations among factors, both orthogonal (varimax) and oblique (oblimin) rotations were performed. Results were the same for both, therefore, only the results of the varimax rotation are reported.

Kaiser's measure of sampling adequacy > .60 heuristic was used to test whether correlations were adequate for EFA (Tabachnick & Fidell, 2013, p. 620). Three iterations

of EFA (principal components, varimax rotation, extraction based on eigenvalues) were conducted. In each iteration, the Kaiser-Meyer-Olkin (KMO) measure exceeded .60: (.92, .90, and .86 respectively) indicating sufficient correlations between variables to proceed with the analysis.

The choice for cutoff for size of factor loading lies with the researcher (Tabachnick & Fidell, p. 654). Comrey and Lee (1992, as stated in Tabachnick and Fidell, p. 654), consider loadings greater than .71 excellent, .63 very good, .55 good, .45 fair, and .32 poor. The cutoff of .63 was selected prior to analysis. In the first iteration of EFA with 24 items of the SDE scale, five factors were extracted explaining 67.22% of the total variance. Four of the 24 items had loadings >.32 on more than one factor: C8, H4, E1, and E8. As well, one item (T2) had factor loadings < .63. These five items were removed from further analysis bringing the item total to 19.

In the second iteration of EFA with 19 items, four factors were extracted explaining 65.25% of the variance. Three of the items had factor loadings >.32 on two or three factors: E2, E9, and C2. One item had factor loadings < .63: E3. These four items were removed from further analysis bringing the item total to 15. None of the items from the original Enables Exploration facet remained following this iteration.

In the third and final iteration of EFA with 15 items, four factors were extracted explaining 70.63% of the total variance. A solution is considered robust if it accounts for at least 50% of the total variance (Tabachnick and Fidell, 2013). None of the items loaded >.32 on more than one factor and each loaded on a single factor >.63. All of the items in the first factor were from the original leads to the unexpected facet (U1, U4, U5, U7, U2) and explained 23.36% of the variance. All of the items of the second factor were from the original highlights triggers facet (H8, H10, H2, H9) and explained 18.05% of the variance. All of the items from the third factor were from the original enables connections facet (C3, C1, C9) and explained 15.50% percent of the variance. Finally, all of the items of the fourth factor were from the original trigger-rich facet (T5, T6, T7) and explained 13.72% of the variance. The communalities (h^2), the proportion of each item's variance that can be explained by the factors, were fairly high, ranging from .62 to .79. Results are shown in Table 24.

Table 24 Results of EFA for SDE items

Item	Factors				h^2
	1	2	3	4	
U1 I bump into unexpected content in it.	**.87**	.09	.09	.08	.77
U4 I come across content by chance in it.	**.82**	.04	.13	.07	.69
U5 I am exposed to unanticipated content in it.	**.81**	.08	.13	.03	.68
U7 I stumble upon information in it.	**.81**	.17	.01	.10	.68
U2 I encounter the unexpected in it.	**.78**	.22	.15	.02	.68
H8 It has features that draw my attention to information.	.20	**.80**	.15	.06	.70
H10 It has features that alert me to information.	.14	**.77**	.14	.05	.64
H2 It has features that ensure that my attention is drawn to useful information.	.07	**.77**	.28	.21	.71
H9 I am pointed toward content in it.	.10	**.75**	.17	.17	.63
C3 I can see connections between topics in it.	.08	.23	**.84**	.17	.79
C1 It enables me to make connections between ideas.	.17	.26	**.82**	.14	.79
C9 I come to understand relationships between ideas in it.	.19	.19	**.82**	.16	.77
T5 It is full of information that is useful to me.	-.03	.03	.16	**.87**	.78
T6 I find information that is of value to me in it.	.16	.13	.08	**.80**	.68
T7 It is a treasure trove of information.	.11	.27	.19	**.71**	.62
Eigenvalues	3.50	2.71	2.33	2.06	
Percentage of variance	23.36	18.05	15.50	13.72	

Note. $N = 289$. U=item from original Leads to the Unexpected facet; H=item from original Highlights Trigger facet; C=item from original Enables Connections facet; T=item from original Trigger-Rich facet; h^2= communalities

Subscale reliability or internal consistency was assessed using Cronbach's alpha (DeVellis, 2003, p. 95-96) with the following results:

- Leads to the unexpected = .89;
- Highlights triggers = .83;
- Enables connections = .86; and
- Trigger-rich = .75.

Cronbach's alpha's ranged from respectable (.70 – .80) to very good (.80 – .90). The mean of each of the four SDE factors extracted through EFA were computed to prepare

them for use as dependent variables in the third and fourth phases of data analysis: **SDE-Leads to the Unexpected**, **SDE-Highlights Triggers**, **SDE-Enables Connections**, and **SDE-Trigger-Rich**.

Summary

With three iterations of EFA, the number of items of the SDE scale was reduced to 15 and four factors were extracted explaining 70.6% of the total variance – a robust solution. H_1 was partially confirmed. EFA confirmed that the serendipitous digital environment is appropriately measured as a four-factor model rather than the five-factor model that was hypothesized. Enables Exploration did not emerge as a distinct factor. In the first two iterations of EFA, the Enables Exploration items either shared too much in common with more than one factor (items E1, E8, E2, E9) or did not meet the selected threshold for a sufficiently high factor loading of .63 (item E3). The four factors that did emerge – Leads to the Unexpected (items=5), Highlights Triggers (items=4), Enables Connections (items=3), and Trigger-Rich (items=3) – had good subscale reliability. These four factors were computed into variables for analysis in Stage 3 and Stage 4:

- **SDE-Leads to the Unexpected**
- **SDE-Highlights Triggers**
- **SDE-Enables Connections**
- **SDE-Trigger-Rich**.

6.4.2 Stage 2: Serendipity Questionnaire Purification

> ***H_2*** *Serendipity is measured appropriately as a three-factor model comprised of serendipity in general, serendipity in digital environments in general, and serendipity in a specific digital environment.*

To test the hypothesis that the Serendipity questionnaire contains three underlying factors, exploratory factor analysis (EFA) was performed. The same procedure described in Stage 1 – EFA (principal components, varimax rotation, extraction based on eigenvalues) – was applied to the eleven serendipity questionnaire items. The Kaiser-Meyer-Olkin (KMO) measure exceeded .60 (KMO = .82) indicating sufficient correlations between variables to proceed with the analysis. Again, results were the same for both orthogonal and oblique rotations; therefore, only the results of the varimax rotation are reported.

Three factors were extracted explaining 71.6% of the variance in a single iteration of EFA. None of the items loaded >.32 on more than one factor and each loaded on a single factor >.63. The factors mirrored the three levels of serendipity. All of the items in the first factor were serendipity in digital environments in general items and explained 25.9% of the variance and had factor loadings ranging from .79 to .81. All of the items in the second factor were serendipity in a specific digital environment items and explained 24.7% of the variance and had factor loadings of .75 to .82. Finally, all of the items in the third factor were serendipity in general items and explained 21.0% of the variance and had factor loadings of .81 to .85. The communalities (h^2) were fairly high, ranging from .61 to .78. Results are shown in Table 25. The internal consistency of each factor was assessed using Cronbach's alpha (DeVellis, 2003, p. 95-96) with the following results:

- Serendipity in digital environments in general = .88;
- Serendipity in a specific digital environment = .83; and
- Serendipity in general = .83.

The mean of each of the three factors extracted through EFA were computed to prepare them for use as dependent variables in the third and fourth stages of data analysis: **Serendipity-DEs**, **Serendipity-Specific DE**, and **Serendipity-General**.

Table 25 Results of EFA on serendipity

Item	Factors			h^2
	1	2	3	
S-DEs2 In digital environments I experience serendipity that has an impact on my work.	**.81**	.27	.19	.77
S-DEs4 In digital environments I experience mixes of unexpectedness and insight that lead to valuable, unanticipated outcomes.	**.81**	.25	.24	.78
S-DEs1 In digital environments I experience serendipity that has an impact on my everyday life.	**.80**	.23	.11	.70
S-DEs3 I encounter useful information, ideas, or resources that I am not looking for when I use digital environments.	**.79**	.14	.25	.71
S-SPE4 In the digital environment I selected, I experience mixes of unexpectedness and insight that lead to valuable, unanticipated outcomes.	.21	**.82**	.12	.73
S-Spe2 In the digital environment I selected, I experience serendipity that has an impact on my work.	.22	**.82**	.08	.72
SDES-Spe3 I encounter useful information, ideas, or resources that I am not looking for when I use the digital environment I selected.	.16	**.76**	.08	.61
S-Spe1 In the digital environment I selected, I experience serendipity that has an impact on my everyday life.	.19	**.75**	-.05	.61
S-Gen3 I encounter useful information, ideas, or resources that I am not looking for.	.18	-.04	**.85**	.76
S-Gen4 I experience mixes of unexpectedness and insight that lead to valuable, unanticipated outcomes.	.18	.08	**.85**	.76
S-Gen2 I experience serendipity that has an impact on my work.	.23	.15	**.81**	.73
Eigenvalues	2.85	2.72	2.31	
Percentage of variance	25.9	24.7	21.0	

Note. $N = 289$.

Summary

In a single iteration of EFA, the number of items of the Serendipity questionnaire was maintained at 11 and three factors were extracted explaining 71.6% of the total variance – a robust solution. H_2 was confirmed – EFA confirmed that serendipity is appropriately measured as a three-factor model, as hypothesized. The three factors that emerged – serendipity in a specific digital environment (items=4), serendipity in digital environments in general (items=4), and serendipity in general (items=3) – had good

subscale reliability. These three factors were computed into variables for analysis in Stage 3 and Stage 4:

- **Serendipity-Specific DE**
- **Serendipity-DEs**
- **Serendipity-General**.

6.4.3 Stage 3: Test Influence of Type of Digital Environment

Once new variables were developed following the EFA analyses of the SDE scale and the Serendipity questionnaire responses, descriptive statistics and correlations of the study variables were computed (Table 26) before proceeding with Stage 3 and 4.

Table 26 Descriptive statistics and correlations of study variables

		M	SD	1	2	3	4	5
1	**SDE-Leads to the Unexpected**	3.96	.78	1				
2	**SDE-Highlights Triggers**	3.65	.82	.33**	1			
3	**SDE-Enables Connections**	3.57	.89	.32**	.50**	1		
4	**SDE-Trigger-Rich**	4.31	.61	.21**	.36**	.40**	1	
5	**Serendipity-Specific DE**	3.21	.78	.64**	.41**	.48**	.34**	1
6	**Serendipity-DEs**	3.68	.76	.32**	.15*	.26**	.15*	.49**
7	**Serendipity-General**	3.40	.68	.11	.05	.16**	.08	.19**
8	**Creative Environment Perceptions**	3.63	.66	.06	.13*	.08	.15*	.09
9	**Openness to Experience**	3.88	.49	.14**	.01	.05	.13*	.14**
10	**Extraversion**	3.47	.59	.09	.11	.10	.22**	.05
11	**Locus of Control of Behaviour**	1.60	.55	-.11	-.06	-.11	-.23**	-.03

		M	SD	6	7	8	9	10	11
6	**Serendipity-DEs**	3.68	.76	1					
7	**Serendipity-General**	3.40	.68	.45**	1				
8	**Creative Environment Perceptions**	3.63	.66	.08	.08	1			
9	**Openness to Experience**	3.88	.48	.08	.07	.08	1		
10	**Extraversion**	3.47	.59	.15*	.22**	.29**	.09	1	
11	**Locus of Control of Behaviour**	1.60	.32	-.01	-.14*	-.33**	-.12*	-.46**	1

Note. $N = 289$.
*$p < .05$; **$p < .01$ (two-tailed)

This third stage sought to answer the third main research question of this thesis:

> ***RQ3*** *Does the type of digital environment in which an individual interacts influence serendipity? And are the perceived characteristics of that digital environment influenced by the type of digital environment?*

H_3 *The* ***DE Type*** *influences individual's ratings of* ***Serendipity-Specific DE***

H_4 *The DE Type influences individual's ratings of the serendipitous digital environment*

a) The ***DE Type*** *influences individual's ratings of* ***SDE-Enables Connections***
b) The ***DE Type*** *influences individual's ratings of* ***SDE-Highlights Triggers***
c) The ***DE Type*** *influences individual's ratings of* ***SDE-Trigger-Rich***
d) The ***DE Type*** *influences individual's ratings of* ***SDE-Leads to the Unexpected***

To test the two hypotheses related to the third research question, a MANOVA analysis was performed will all eleven variables contained in Table 26 above:

- The three serendipity variables
  - **Serendipity-Specific DE**
  - **Serendipity-DEs**
  - **Serendipity-General**
- The four SDE variables:
  - **SDE-Leads to the Unexpected**
  - **SDE-Highlights Triggers**
  - **SDE-Enables Connections**
  - **SDE-Trigger-Rich**
- **Creative Environment Perceptions**
- **Locus of Control of Behaviour**
- **Extraversion**
- **Openness to Experience**

The independent variable was **DE Type**. Only those datasets (*N*=254; 87.9%) in which participants selected digital environments (**DE Type**) that fell into the five main types were analysed (Table 27). Comparisons of digital environments in which the type was unclear (*N*=13, 4.5%), multiple digital environments spanning two or more of the main types of digital environments (*N*=15, 5.2%), and a handful of digital environments that

did not fit into the five main categories (N=7, 2.4%) would not yield interpretable results and therefore were left out of the analysis.

Table 27 DE Type by Survey Group

DE Type	Survey Group 1 (specific information)	Survey Group 2 (unplanned information)	N (% of Total)
Databases	59 (79.7%)	15 (20.3%)	74 (26%)
Social media	13 (18.8%)	56 (81.2%)	69 (24%)
Search engines	28 (58.3%)	20 (41.7%)	48 (17%)
Websites	20 (47.6%)	22 (52.4%)	42 (15%)
Intranets	13 (61.9%)	8 (38.1%)	21 (7%)
Multiple	10 (66.7%)	5 (33.3%)	15 (5%)
Unclear	5 (38.5%)	8 (61.5%)	13 (4%)
Other	3 (42.9%)	4 (57.1%)	7 (2%)
Total	**149 (52.1%)**	**137 (47.9%)**	**289 (100%)**

Results of the MANOVA are displayed in Table 28. Using Wilk's criterion the composite dependent variate was significantly affected by **DE Type**, Wilk's λ, F[44, 916.31) = 3.62, $p < .001$, partial $\eta^2 = .14$.

Univariate ANOVAs were conducted on each dependent measure separately to determine the cause for the significant multivariate effect. **DE Type** significantly affected three of the four underlying factors of the proposed SDE scale:

- **SDE-Leads to the Unexpected**, $F(4, 249) = 13.61$, $p < .001$, partial $\eta^2 = .18$;
- **SDE-Enables Connections**, $F(4, 249) = 3.83$, $p < .01$, partial $\eta^2 = .06$; and
- **SDE-Trigger-Rich**, $F(4, 249) = 6.14$, $p < .001$, partial $\eta^2 = .09$.

DE Type did not significantly affect **SDE-Highlights Triggers**.

DE Type significantly affected one of the three underlying factors of serendipity:

- **Serendipity-Specific DE**, $F(4, 249)=11.47$, $p < .001$, partial $\eta^2 = .16$.

DE Type did not significantly affect **Creative Environment Perceptions**, **Extraversion**, or **Locus of Control of Behaviour**, but it did significantly affect one of the individual differences – **Openness to Experience**:

- **Openness to Experience**, $F(4, 249) = 2.90$, $p < .05$, partial $\eta^2 = .04$.

Table 28 Multivariate and univariate analysis of variance for the eleven dependent variables as a function of DE Type

	Multivariate	*Univariate*			
Source	F^a	*TRIGG*	*CONN*	*HIGH*	*UNEX*
DE Type	3.62	6.14***	3.83**	1.16	13.61***
MSE		2.10	2.88	0.76	7.33

	Multivariate	*Univariate*		
Source	F^a	*S-Spe*	*S-DEs*	*S-Gen*
DE Type	3.62	11.47***	1.51	1.00
MSE		6.45	.87	.46

	Multivariate	*Univariate*			
Source	F^a	*EXTRA*	*OPEN*	*CEP*	*LCB*
DE Type	3.62	.27	2.90*	.91	.39
MSE		.10	.65	.38	.11

Note. $N = 254$.

UNEX=**SDE-Leads to the Unexpected**; HIGH=**SDE-Highlights Triggers**; CONN=**SDE-Enables Connections**; TRIGG=**SDE-Trigger-Rich**; S-SPE=**Serendipity-Specific DE**; S-DEs=**Serendipity-DEs**; S-Gen=**Serendipity-General**; EXTRA=**Extraversion**; OPEN=**Openness to Experience**; CEP=**Creative Environment Perceptions**; LCB=**Locus of Control of Behaviour**

Multivariate *F* ratios were generated from Wilk's criterion.

a. Multivariate $df = 44, 916.31$.

b. Univariate $df = 4, 249$

*$p < .05$; **$p < .01$; ***$p < .001$. (2-tailed)

Table 29 Mean scores and standard deviations for the eleven dependent variables as a function of DE Type

	TRIGG		***CONN***		***HIGH***		***UNEX***	
DE Type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Websites	4.48[a]	.46	3.92[e]	.75	3.73	.85	4.06[h]	.78
Intranets	3.94[b]	.65	3.14[f]	1.09	3.44	.90	3.47[i]	.70
Databases	4.46[c]	.51	3.56	.81	3.54	.75	3.62[j]	.72
Search engines	4.31	.60	3.33[g]	1.00	3.68	.88	3.82[k]	.85
Social media	4.12[d]	.69	3.57	.82	3.76	.77	4.42[l]	.63

	S-Spe		***S-DEs***		***S-Gen***	
DE Type	*M*	*SD*	*M*	*SD*	*M*	*SD*
Websites	3.25[m]	.72	3.59	.78	3.58	.78
Intranets	2.62[n]	.63	3.64	.71	3.41	.45
Databases	2.89[o]	.71	3.60	.79	3.37	.65
Search engines	3.16[p]	.79	3.63	.76	3.44	.65
Social media	3.61[q]	.81	3.87	.73	3.34	.71

	EXTRA		***OPEN***		***CEP***		***LCB***	
DE Type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Websites	3.50	.57	3.86	.50	3.68	.59	1.54	.47
Intranets	3.43	.47	3.61[r]	.56	3.70	.64	1.55	.43
Databases	3.51	.61	3.90	.44	3.52	.69	1.65	.51
Search engines	3.47	.56	3.83	.50	3.72	.59	1.58	.59
Social media	3.41	.66	3.99[s]	.45	3.62	.65	1.58	.60

Note. $N = 254$.
Means with different superscripted letters differed significantly at the .05 level (2-tailed) by means of Tukey HSD post hoc test

Table 29, above, contains the mean scores and standard deviations for the eleven dependent variables as a function of **DE Type**. Means with different superscripted letters differed significantly with another variable at the .05 level by means of Tukey HSD post hoc test. Only those variables with significant results are explored in the following sections: **SDE-Trigger-Rich**, **SDE-Enables Connections**, **SDE-Leads to the Unexpected**, **Serendipity-Specific DE**, and **Openness to Experience**.

SDE-Trigger-Rich *post hoc:*

Tukey HSD post hocs suggested that there were significant differences in **SDE-Trigger-Rich** scores among four **DE Types** with intranets with the lowest mean scores and websites with the highest mean scores. The mean **SDE-Trigger-Rich** score for websites (M = 4.48, SD = .46) was significantly different than **SDE-Trigger-Rich** scores for intranets (M = 3.94, SD = .65) and social media (M = 4.16, SD = .69). Databases (M = 4.46, SD = .51) differed significantly from intranets (M = 3.94, SD = .65) and social media (M = 4.16, SD = .69). These results suggest that the **DE Type** has an effect on individual's perceptions of their environment as trigger-rich. Specifically, the perception of trigger-rich is higher in websites than in intranets or social media. As well, the perception of the digital environment as trigger-rich is higher in databases than in intranets or social media.

Enables Connections *post hoc:*

Tukey HSD post hocs suggested that there were significant differences in **SDE-Enables Connections** scores among three types of digital environments with intranets with the lowest mean scores and websites with the highest mean scores. The mean **SDE-Enables Connections** score for websites (M = 3.92, SD = .75) was significantly different than **SDE-Enables Connections** scores for intranets (M = 3.14, SD = 1.09) and search engines (M = 3.33, SD = 1.00). These results suggest that the **DE Type** has an effect on an individual's perceptions of how well the digital environment enables connections. Specifically, the perception of how well a digital environment enables connections is higher in relation to websites than in intranets or search engines.

Leads to the Unexpected *post hoc:*

Tukey HSD post hocs suggested that there were significant differences in **SDE-Leads to the Unexpected** scores among the five types of digital environments with intranets with the lowest mean scores and social media with the highest mean scores. The mean **SDE-Leads to the Unexpected** score for social media (M = 4.42, SD = .63) was significantly different than **SDE-Leads to the Unexpected** scores for intranets (M = 3.47, SD = .70), databases (M = 3.62, SD = .72), and search engines (M = 3.82, SD = .85). The mean **SDE-Leads to the Unexpected** score for websites was significantly different than that for

intranets (M = 3.47, SD = .70) and databases (M = 3.62, SD = .72). These results suggest that the **DE Type** has an effect on individual's perceptions of how well the digital environment leads to the unexpected. Specifically, the perception of leads to the unexpected is higher in social media than in intranets, databases, and search engines. Moreover, the perception of leads to the unexpected is higher in websites than in intranets or databases.

Serendipity-Specific DE *post hoc:*

Tukey HSD post hocs suggested that there were significant differences in scores on the **Serendipity-Specific DE** between all five types of digital environments with intranets with the lowest mean scores and social media with the highest mean scores. The mean **Serendipity-Specific DE** score for social media (M = 3.61, SD = .81) was significantly different than **Serendipity-Specific DE** scores for databases (M = 2.89, SD = .71), search engines (M = 3.16, SD = .79), and intranets (M = 2.62, SD = .63). Intranets (M = 2.62, SD = .63) also differed significantly from websites (M = 3.25, SD = .72) and search engines (M = 3.16, SD = .79). These results suggest that the **DE Type** has an effect on individual's perceptions of their environment in relation to serendipity. Specifically, users perceive serendipity occurs more frequently in social media than in databases, search engines, or intranets. Moreover, users perceive serendipity occurs less frequently in intranets than in websites or search engines.

Openness to Experience *post hoc:*

Tukey HSD post hocs suggested that there were significant differences in scores on **Openness to Experience** between two types of digital environments with intranets with the lowest mean scores and social media with the highest mean scores. The mean **Openness to Experience** score for social media (M = 3.99, SD = .45) was significantly different than **Openness to Experience** scores for intranets (M = 3.61, SD = .56). These results suggest that the **DE Type** has an effect on **Openness to Experience**. Specifically, the **Openness to Experience** is higher in social media than in intranets.

Summary

H_3 was confirmed – **DE Type** influenced individual's ratings of serendipity in the digital environment they selected to assess (**Serendipity-Specific DE**). Moreover, serendipity

was perceived to occur more frequently in some digital environments than others – namely, in social media versus databases, search engines, or intranets and in websites and search engines versus intranets. Results suggest that there may be common features or functions of digital environments that underlie these perceptions.

H_4 was partially confirmed. The type of digital environment (**DE Type**) selected does make a difference in participants' perceptions of three of the proposed facets of a serendipitous digital environment: how trigger-rich a digital environment is, how well it enables connections, and leads to the unexpected. **DE Type** did not have a significant effect on perceptions of how well a digital environment highlights triggers.

As well, a relationship was found between **DE Type** and **Openness to Experience** that had not been hypothesized: participants who selected a social media DE had higher levels of openness to experience than those who selected intranets. Due to a cell count, however, that fell below the recommended value, more research is required to confirm these results.

6.4.4 Stage 4: Exploration of Relationships between Serendipity, Environment, and Individual Differences

RQ4 *What relationships exist between serendipity and the underlying facets of a serendipitous digital environment, the individual's broader work environment, locus of control, openness to experience, and extraversion?*

H_5 Serendipity-Specific DE *will be positively associated with the underlying factors of a serendipitous digital environment,* ***Creative Environment Perceptions****,* ***Locus of Control of Behaviour****,* ***Openness to Experience****, and* ***Extraversion****.*

H_6 Serendipity-DEs *will be positively associated with* ***Creative Environment Perceptions****,* ***Locus of Control of Behaviour****,* ***Openness to Experience****, and* ***Extraversion****.*

H_7 Serendipity-General *will be positively associated with* ***Creative Environment Perceptions****,* ***Locus of Control of Behaviour****,* ***Openness to Experience****, and* ***Extraversion****.*

Three multiple regression analyses were performed to test H_5, H_6, and H_7 using the three serendipity variables as the dependent variables – **Serendipity-Specific DE, Serendipity-DEs**, and **Serendipity-General** – and eight independent dependent variables: **SDE-Enables Connections**, **SDE-Highlights Triggers**, **SDE-Trigger-Rich**, **SDE-Leads to**

the Unexpected, **Creative Environment Perceptions**, **Locus of Control of Behaviour**, **Extraversion**, and **Openness to Experience**. The results of the three regression analyses are described below.

1) Relationships to Serendipity in Specific Digital Environments

This regression was performed to explore whether there is a relationship between participants' perceptions of how frequently serendipity occurs in the digital environment they selected (e.g., Twitter, PubMed, Google Scholar, their work intranet) (**Serendipity-Specific DE**) and their perceptions of the underlying factors of the SDE (**SDE-Enables Connections**, **Highlights Triggers**, **Trigger-Rich**, **Leads to the Unexpected**), **Creative Environment Perceptions**, **Openness to Experience**, **Extraversion**, and **Locus of Control of Behaviour**. The independent variables explain 51% of the variance of how frequently serendipity occurs in the digital environment they selected, but only **SDE-Leads to the Unexpected**, **SDE-Enables Connections**, and **SDE-Trigger-Rich** make a significant contribution to the model (Table 30).

Table 30 Multiple regression results with S-Specific DEs as the dependent variable

Variable	*B*	*SEB*	*Beta*
SDE-Leads to the Unexpected	.51	.05	.51**
SDE-Highlights Triggers	.08	.05	.09
SDE-Enables Connections	.20	.05	.23**
SDE-Trigger-Rich	.17	.06	.13*
Creative Environment Perceptions	.05	.05	.05
Openness to Experience	.08	.07	.05
Extraversion	-.04	.06	-.03
Locus of Control of Behaviour	.13	.07	.09

Note..$R^2 = .51$. ($N = 289$, $p < .001$)
*$p < .01$; **$p < .001$

H_5 was partially confirmed. It was hypothesized that **Serendipity-Specific DE** would have a relationship with the underlying factors of the SDE, **Creative Environment Perceptions**, **Openness to Experience**, **Extraversion,** and **Locus of Control of Behaviour**. However, **Serendipity-Specific DE's** relationship was only confirmed with

three of the four underlying factors of the SDE (**SDE- Leads to the Unexpected, SDE-Enables Connections,** and **SDE-Trigger-Rich**).

2) Relationships to Serendipity in Digital Environments

This multiple regression analysis was performed to explore whether there is a relationship between participants' perceptions of how frequently serendipity occurs in digital environments in general and their perceptions of the underlying factors of the SDE, **Creative Environment Perceptions**, **Openness to Experience, Extraversion,** and **Locus of Control of Behaviour**. The variables explain just 12% of the variance in how frequently serendipity occurs in digital environments in general. Only **SDE-Leads to the Unexpected** and **SDE-Enables Connections** make a significant contribution to the model (Table 31).

Table 31 Multiple regression results with S-DEs as the dependent variable

Variable	***B***	***SEB***	***Beta***
SDE-Leads to the Unexpected	.25	.06	.26**
SDE-Highlights Triggers	-.04	.06	-.04
SDE-Enables Connections	.15	.06	.17*
SDE-Trigger-Rich	.02	.08	.02
Creative Environment Perceptions	.02	.07	.02
Openness to Experience	.03	.09	.02
Extraversion	.14	.08	.11
Locus of Control of Behaviour	.00	.09	.00

Note. $R^2 = .12$. ($N = 289$, $p < .001$)
* $p < .01$; ** $p < .001$

H_6 was not confirmed. It was hypothesized that **Serendipity-DEs** would have a relationship with **Creative Environment Perceptions**, **Openness to Experience**, **Extraversion**, and **Locus of Control of Behaviour**, but none did. Though not hypothesized, a relationship, though weak, was found between **Serendipity-DEs** and **SDE-Leads to the Unexpected** and **SDE-Enables Connections**.

3) Relationships to Serendipity in General

This regression analysis was performed to explore whether there is a relationship between participants' perceptions of how frequently serendipity occurs in general, irrespective of their environment, and their perceptions of the underlying factors of the SDE, **Creative Environment Perceptions**, **Openness to Experience**, **Extraversion**, and **Locus of Control of Behaviour**. The variables explain just 5% of the variance in responses to **Serendipity-General** and only **SDE-Enables Connections** and **Extraversion** make a significant contribution to the model (Table 32).

Table 32 Multiple regression results with S-General as the dependent variable

Variable	***B***	***SEB***	***Beta***
SDE-Leads to the Unexpected	.05	.06	.06
SDE-Highlights Triggers	-.06	.06	-.07
SDE-Enables Connections	.12	.05	.16*
SDE-Trigger-Rich	-.02	.05	-.02
Creative Environment Perceptions	.02	.06	.02
Openness to Experience	.04	.08	.03
Extraversion	.22	.08	.19**
Locus of Control of Behaviour	-.04	.08	-.03

Note. $R^2 = .05$. ($N = 289$, $p < .01$)
*$p < .05$; **$p < .01$

H_7 was partially confirmed. It was hypothesized that **Serendipity-General** would have a relationship with **Creative Environment Perceptions**, **Openness to Experience**, **Extraversion**, and **Locus of Control of Behaviour**, but only **Extraversion** was confirmed to have a relationship. Though not hypothesized, a relationship, though weak, was also found between **Serendipity-General** and **SDE-Enables Connections**.

6.5 Summary

The study described in this chapter sought to purify and evaluate the reliability and construct validity of the SDE scale and Serendipity questionnaire developed in Chapter 5. The SDE scale was reduced from 37 to 15 items. Four of the original five facets were extracted in three iterations of EFA: leads to the unexpected, highlights triggers, enables

connections, and trigger-rich. The enables exploration facet items double loaded on other factors during the three iterations of EFA and thus it may be concluded that this facet is captured by the other factors or that items developed for this facet need to be strengthened and made more distinct.

This study further sought to answer two research questions:

> ***RQ3*** *Does the type of digital environment in which an individual interacts influence serendipity? And are the perceived characteristics of that digital environment influenced by the type of digital environment?*
>
> ***RQ4*** *What relationships exist between serendipity and the underlying facets of a serendipitous digital environment, the individual's broader work environment, locus of control, openness to experience, and extraversion?*

In response to RQ3, MANOVA results indicate that some types of digital environments may be more conducive to serendipity than others and ratings of the facets of a serendipitous digital environment vary by type of digital environment. This result gives credence to the belief that common features and functions of digital environments may underlie these perceptions and further suggests that it may be possible to design digital environments to support serendipity. Multiple regression analyses helped respond to RQ4 and results indicate relationships exist between participants' perceptions of how frequently serendipity occurs (**Serendipity-Specific DE**) and factors relating to the proposed serendipitous digital environment (**SDE-Leads to the Unexpected, SDE-Enables Connections,** and **SDE-Trigger-Rich**). No relationship was found between **SDE-Highlights Triggers** and **Serendipity-Specific DE**, challenging the hypothesis that a digital environment that points to or alerts users to interesting information supports serendipity. No relationship was found between **Creative Environment Perceptions**, Extraversion, or **Locus of Control of Behaviour** and **Serendipity-Specific DE**. Finally, while no relationship was found between **Serendipity-Specific DE** and **Openness to Experience**, those who selected a social media DE had higher levels of **Openness to Experience** than those who selected intranets. The findings of this study will be discussed in greater detail and integrated with the prior research in the following chapter.

CHAPTER 7. SUMMARY AND DISCUSSION

7.1 Overview

This research examined the phenomenon of work-related serendipity, investigating how it unfolds and how it is facilitated in digital environments and what role individual differences play. The findings of this research support previous models of serendipity and highlight the most salient elements of the process of serendipity that are relevant to the development of support for the process. The results confirm the role that characteristics of a digital environment play in serendipity and underline the importance of the design and development of information technology and interfaces that support serendipity; however, more research is needed to pinpoint what specific features and functions of digital environments support serendipity. Furthermore, how individual differences influence serendipity remains difficult to pin down. This chapter first summarizes the findings from the research questions followed by a discussion organized by the two main themes in this research: 1) individual differences and serendipity and 2) environment and serendipity.

7.2 Summary of Findings

7.2.1 Research Question 1

RQ1 How does work-related serendipity unfold and what aspects of the individual and the environment are likely to influence this process?

Five main elements of the process of serendipity were identified and summarized in the model (Figure 3) and are defined as:

- *Trigger:* A verbal, textual, or visual cue that initiates or sparks serendipity.
- *Connection:* The recognition of a relationship between the *Trigger* and the individual's knowledge and experience.
- *Follow-up:* The actions an individual takes to pursue *Trigger/Connection* and obtain a *Valuable outcome*.
- *Valuable Outcome:* The positive effect of the serendipitous experience.
- *Unexpected Thread:* The unexpected, chance, accidental, or surprising element that is evident in one or more of the four other elements of the serendipitous experience.

The aspects of the individual and environment that *may* influence each stage of the process of serendipity were identified:

Individual (see also Table 5):

- *Prepared mind:* The individual's knowledge and experience that may help facilitate serendipity in the Trigger, Connection, and Follow-up elements of the process of serendipity and may also contribute to the Unexpected Thread element.
- *Unfocused attention:* A temporary state in which an individual's attention is not directed toward a specific goal that may facilitate the Trigger and Unexpected Thread elements of serendipity.
- *Ability to make connections:* To be able to think critically or creatively about relationships between encountered ideas, information, and phenomena and the individual's own knowledge and experience. The ability to make connections appears important to serendipity in the Connection, Follow-up, and Unexpected Thread elements of the process.
- *Openness:* To be open to experience, curious, receptive, and have a relaxed nature. Like the prepared mind, openness appears to facilitate the Trigger, Connection, Follow-up and Unexpected Thread elements of the process of serendipity.

Environment (see also Table 6):

- *Trigger-Rich:* Contains sensory cues that have the potential to spark serendipity and supports the Trigger and Unexpected Thread elements of the process of serendipity.
- *Highlights Triggers:* Highlights, points to, or otherwise alerts an individual to Triggers and, like Trigger-Rich, appears to support the Trigger and Unexpected Thread elements of the process of serendipity.
- *Enables Connections:* Juxtaposes information and ideas to help an individual make connections. This aspect of the environment appears to facilitate the Connections elements of the process of serendipity as well as the Follow-up and Unexpected Thread elements.
- *Open:* Encourages exploration, critical thinking, and the sharing of knowledge and ideas. Being open may enable the Trigger, Connection, Follow-up, and Unexpected Thread elements of the process of serendipity.

The first research question and its resultant findings led to a more holistic understanding of serendipity, a long-view of serendipity that included more than just the information

encounter, but what leads up to it, what follows, as well as what may drive it. This prompted the development of the remaining research questions that sought to explore and confirm the characteristics of the individual and the environment that influence serendipity.

7.2.2 Research Question 2

While established psychometric tests are available to measure many of the qualities that have been linked to the serendipity-prone person, no measurement tool currently exists to evaluate the likelihood of a webpage, device, or system to foster serendipity. Before the influence of characteristics of digital environments on serendipity could be tested, these characteristics needed to be isolated and tools to measure them had to be developed. This led to the second research question:

RQ2 *How do we measure the characteristics of a digital environment that have the potential to support serendipity? And what are these characteristics?*

Five preliminary facets of a serendipitous digital environment were identified based on findings from Study 1 and the prior research, each with the potential to influence parts of the process of serendipity: Enables Exploration, Trigger-Rich, Highlights Triggers, Enables Connections, and Leads to the Unexpected. Items, statements to be used in a self-report questionnaire, were developed to reflect the conceptual space of each of these facets and thus reflect the broader conceptual space of the serendipitous digital environment.

Through the findings of two studies in Phase 2 – the expert review (Study 2) and the ANOVA approach (Study 3) – the preliminary five facets of the SDE were confirmed and their definitions and items were revised:

- *Enables Exploration:* A user's assessment of the degree to which a digital environment supports exploration and examination of its information, ideas, or resources.
- *Trigger-Rich:* A user's assessment of the degree to which a digital environment contains a variety of information, ideas, or resources that is interesting and useful to the user.

- *Highlights Triggers:* A user's assessment of the degree to which a digital environment brings interesting and useful information, ideas, or resources to the user's attention.
- *Enables Connections:* A user's assessment of the degree to which a digital environment makes relationships or connections between information, ideas, or resources apparent.
- *Leads to the Unexpected:* A user's assessment of the degree to which a digital environment provides opportunities for unexpected interactions with information, ideas, or resources.

Results of the exploratory factor analysis (EFA) in the fourth and final study indicated that four of the five facets above were distinct, though correlated, after three iterations of EFA:

- Trigger-Rich [3 items]
- Enables Connections [3 items]
- Highlights Triggers [4 items]
- Leads to the Unexpected [4 items]

The fifth proposed facet, Enables Exploration, did not emerge as a distinct factor.

To test the construct validity of the underlying factors of the proposed SDE – to check whether these factors of a digital environment facilitate serendipity – another set of self-reported questionnaires designed to measure serendipity was developed and then applied in the final web-based study. Serendipity was measured by its perceived frequency on three levels:

- Level 1 - Serendipity in a Specific DE: the participant's perception of how frequently serendipity occurs in a specific digital environment;
- Level 2 - Serendipity in DEs in General: the participant's perception of how frequently serendipity occurs in digital environments in general; and,
- Level 3 - Serendipity in General: the participant's perception of how frequently serendipity occurs in general.

Results of EFA in the final study confirmed the three levels of serendipity are distinct yet correlated. Furthermore, while **SDE-Trigger-Rich**, **SDE-Enables Connections**, and **SDE-Leads to the Unexpected** were related to the frequency of serendipity in a specific digital environment (**Serendipity-Specific DE**), **SDE-Highlights Triggers** was not. Thus, in answer to RQ2, it is possible to measure the characteristics of a digital

environment that have the potential to support serendipity using the SDE scale, comprised of the underlying factors of **SDE-Trigger-Rich**, **SDE-Enables Connections**, and **SDE-Leads to the Unexpected**, though more research to test the validity of the SDE scale is needed.

7.2.3 Research Question 3

Research in response to RQ2 led to the development and validation of a preliminary tool to measure the serendipitous digital environment as well as serendipity, but I was interested in applying the serendipitous digital environment scale to discover whether the type of digital environment (e.g., website versus social media site) and thus the common features and functions that characterize different digital environments influence serendipity. Therefore, the third research question focused on types of digital environments and their perceived characteristics.

RQ3 *Does the type of digital environment in which an individual interacts influence serendipity? And are the perceived characteristics of that digital environment influenced by the type of digital environment?*

In answer to RQ3, the type of digital environment (database, website, social media, search engine, work intranet) did influence serendipity. **Serendipity in a Specific DE** and the underlying factors of the SDE scale were also influenced by the type of digital environment that it is (e.g., work intranet versus social media). The type of digital environment (**DE Type**) influenced three of the four proposed underlying factors of the proposed SDE: **SDE-Leads to the Unexpected**, **SDE-Enables Connections**, and **SDE-Trigger-Rich**. The type of digital environment did not influence how participants perceived the digital environment they assessed relating to **SDE-Highlights Triggers**.

Though no specific research question or hypotheses were developed, the influence of the type of digital environment on the other variables from Study 4 was also explored. I found that participants' level of **Openness to Experience** (Lee & Ashton, 2004) influenced the type of digital environment (**DE Type**) participants selected to assess, though more research is needed to confirm these results.

7.2.4 Research Question 4

Neither the individual nor the environment can solely explain serendipity. Neither is it possible to completely isolate the two. Therefore, RQ4 was formulated to address this complex interaction:

RQ4 *What relationships exist between serendipity and the underlying facets of a serendipitous digital environment, the individual's broader work environment, locus of control, openness to experience, and extraversion?*

Some relationships were found between serendipity and the underlying factors of the SDE scale. These relationships were strongest for **Serendipity-Specific DE** where the study variables explained 51% of the variance in responses to serendipity in the digital environment selected and assessed by participants. Level 2 (**Serendipity-DEs**) and Level 3 (**Serendipity-General**), in contrast, explained just 12% and 5% of the variance of the models respectively. Table 33 provides an overview of the results. See Tables 30 to 32 for more detailed results.

Level 1 (**Serendipity-Specific DE**): There was a significant relationship between **Serendipity-Specific DE** and **SDE-Leads to the Unexpected**, **SDE-Enables Connections**, and **SDE-Trigger-Rich** and these variables together explained 51% of the variance in responses to the frequency of serendipity explained in the digital environments selected by participants. **SDE-Highlights Triggers**, **Creative Environment Perceptions** (Mayfield & Mayfield, 2010), **Extraversion** (Lee & Ashton, 2004), **Locus of Control of Behaviour** (Craig et al., 1984), and **Openness to Experience** (Lee & Ashton, 2004), however, showed no significant relationship to **Serendipity-Specific DE**.

Level 2 (**Serendipity-DEs**): There was a significant relationship between **Serendipity-DEs** and **SDE-Leads to the Unexpected** and **SDE-Enables Connections**, but none of the other variables relating to the environment or the individual. Together, these variables explained just 12% of the variance in responses to the frequency of serendipity in digital environments in general.

Level 3 (**Serendipity-General**): There was a significant relationship between **Serendipity-General** and **SDE-Enables Connections** and **Extraversion**, though none of the other variables. Furthermore, these variables explain only 5% of the variance in responses to the frequency of serendipity in general.

Table 33 Summary of multiple regression results of the relationship between serendipity on three levels and the study variables

	Level 1: **Serendipity-Specific DE**	Level 2: **Serendipity-DEs**	Level 3: **Serendipity-General**
SDE-Enables Connections	✓	✓	✓
SDE-Trigger-Rich	✓	X	X
SDE-Leads to the Unexpected	✓	✓	X
SDE-Highlights Triggers	X	X	X
Creative Environment Perceptions	X	X	X
Locus of Control of Behaviour	X	X	X
Extraversion	X	X	✓
Openness to Experience	X	X	X
Percentage of variance explained by variables in multiple regression analyses	**51%**	**12%**	**5%**

7.3 Discussion of Findings

Serendipity is an unexpected experience prompted by an individual's valuable interaction with ideas, information, objects, or phenomena. More specifically, serendipity is a positive, unexpected experience characterized by an underlying process that is discernable in retrospect. The process is set in motion by an individual's

valuable interaction with a trigger or perceptual cue that jogs the individual to make a connection between the trigger and that individual's knowledge and experience. In the case of work-related serendipity where the impact is felt by the individual as well as an organization or community, further work or follow-up may be necessary to reach desired, valuable outcomes. The unexpected, chance, accidental, or surprising element that characterizes serendipity may be experienced during the trigger, connection, follow-up, or valuable outcome stage of the process and contribute to the individual's perception of the experience as serendipitous.

We can see how the process of serendipity unfolds through the example provided by the journalist (Chapter 4). He stumbled upon an unsubstantiated claim (trigger) in Wikipedia about the local origin of an internationally famous song. His experience as a journalist prompted him to make a connection – he understood the importance of finding a local angle to an international story. It took work, though. He had to investigate and verify the claim and write it up in an article for a local paper (follow-up). But overall, the experience was a positive one and he found value in it – it was a fun mystery to solve and he was able to bring attention to a piece of near-forgotten history (valuable outcome). Furthermore, there were surprises along the way. The claim that there was a connection between his home province and the famous song was surprising to him and he expected to find that the Wikipedia article was incorrect when he followed up on the claim (unexpected thread).

As the journalist's example illustrates, the phenomenon of serendipity is complex. But while each example of serendipity is unique, they do share common elements that make it possible to discover what influences the process of serendipity and, for the purposes of this research, how serendipity may be supported in digital environments. This thesis research isolated a number of internal and external variables to explore what influences it and found that the characteristics of a digital environment play a significant role in serendipity. The frequency of serendipity varied by type of digital environment, e.g., social media site versus an organization's intranet, which further suggests that environment matters. Control often emerges as important theme in discussions of serendipity and efforts to support serendipity but this research did not find individual's

locus of control of behaviour influences perceptions of serendipity. While interviews with academics and professionals indicated that an individual's broader work environment shapes serendipity, this finding was not supported in a larger survey study that employed a measure of the creative environment (Mayfield & Mayfield, 2010). Openness, a quality of the individual evident in the investigative study, was also unconfirmed in the larger study that used a validated measure of openness to experience (Lee & Ashton, 2004). While extraversion (Lee & Ashton, 2004) did have a significant relationship with how frequently serendipity occurs in general, its effect size was small. The following sections discuss these findings within the context of prior research by considering the two main themes in this thesis relating to what influences serendipity, namely, individual differences and environments.

7.3.1 Individual Differences and Serendipity

Individual differences have often been included in both definitions and models of serendipity, but isolating them is an important step toward identifying what influences serendipity. The investigative study (Chapter 4) helped to illuminate how individual differences may shape serendipity. As in prior research (e.g., Rubin et al., 2011), the importance of the *prepared mind* in serendipity was evident. While potential triggers for serendipity may abound, they will be meaningless unless the individual can make connections between the information, ideas, objects, or phenomenon encountered and their own knowledge and experience – the prepared mind. The investigative study, however, also revealed the prepared mind is a double-edged sword, threatening to hinder serendipity. While having enough knowledge and experience to recognize the importance of the information encountered facilitates serendipity (McBirnie, 2008), preconceptions may inhibit serendipity (Barber & Fox, 1958). Eco (1998) refers to our knowledge and previous experience as our *background books* – our "preconceived notions of the world, derived from our cultural tradition" (p. 54) through which we interpret and explain what we encounter in the world. Our background books help us to recognize connections but also potentially prevent us from seeing something new. A similar point was raised more recently in the context of information filtering and personalization. Rather than an individual's own background books, Pariser (2011) argued that the computer technology

developed to curate the information we are exposed to creates a *filter bubble* that limits the sort of information we encounter and also prevents us from seeing something new.

Whether our background books delay connections we might make or connections are preempted altogether through lack of exposure to a variety of information and ideas, the ability of a person to make connections through creative or critical thinking was also identified in the investigative study as an important factor in serendipity, particularly in relation to connections that require a significant cognitive leap. A *known problem connection* in which a connection between the trigger and a worker's previously identified or current problems are obvious requires much less creative cognitive ability than a *new direction connection* in which the problem was previously unidentified and represents something novel. The latter explains why there may be a delay – it takes time to recognize the connection between the trigger and one's own work. The delay is similar to information processing findings that indicate that while we may read, we may not necessarily become fully conscious of what we have read right away. There may be a *time lag* between unconscious and conscious information processing (Cole, 1997), time to realize the relationship between the trigger(s) and one's knowledge and experience.

The delay may also be explained by the quality of openness, which was evident in the investigative study and reflects findings from other studies that suggest a relationship between serendipity and receptivity to external stimulus. Inquisitiveness is a characteristic of an open personality (Ashton & Lee, 2007) and this relationship has been further identified in research that connects information seeking to information encountering (Pálsdóttir, 2010), information seeking to incidental exposure to news (Lee, 2009), and an inquisitiveness to information encountering (Erdelez, 1995). While a relationship was found between the type of digital environment selected by participants and openness, no relationship was found between openness to experience and serendipity in the final web-based study (Study 4).

In Study 4, the large, web-based survey, those with higher levels of openness to experience were more likely to select a social media site to assess than those closed to experience suggesting perhaps those open to experience are more likely to use social media or find it useful in their work. Though not anticipated, this result makes sense

relative to prior research that indicates that those more open to experience were more likely to use social media (Amichai-Hamburger & Vinitzky, 2010). While people who are open to experience may use social media more than those closed to experience, those who are closed to experience are just as likely to have serendipitous experiences within social media sites as their more open counterparts. It may be that digital environments have an equalizing effect in which personality may be less important than characteristics of the digital environment in enabling serendipity.

The cumulative qualitative evidence in prior research of an association between openness and serendipity, however, cannot be dismissed. While openness as a personality trait may not be an important factor in serendipity, other forms of openness may be – those grounded in personal strategy or situation rather than personality, for example. Openness to experience may be encouraged, for example, through incentives and practice over time (McCrae, 1987). Professionals and academics, the focus of this PhD thesis, have incentives to be open to experience relative to their work, motivations to keep an eye out for information and ideas that might be useful to their work and research and possibly have training to do just that leading to equal opportunity for serendipity despite differences in personality.

The situational nature of serendipity was also reflected in the identification of unfocused attention in several of the examples in the investigative study. While it may be the case that individuals must possess the attentional ability to notice something outside their primary activity (Rubin et al., 2011), this research found that while noticing may *lead* one to lose focus and turn one's attention elsewhere, noticing also occurs *during* periods of unfocused attention such as taking a break. These findings are supported by a study (Dantonio, Makri, & Blandford, 2012) in which 15 postgraduates were interviewed about their experience of encountering academic social media content serendipitously that found that taking a break or relaxing by browsing the web – "unfocussed browsing" – or going onto social media sites provided opportunities for serendipity. It was not possible to capture this aspect of the situational nature of serendipity in the type of self-report questionnaires administered in Study 4 (Chapter 6).

Like openness to experience, it was diffficult to conclude from the investigative study whether participants' descriptions of the social activities intrinsic to their serendipitous experiences were simply situational in nature or pointed to the personality trait of extraversion. Extraversion as a personality trait has been related to incidental information acquisition (Heinström, 2006) and the investigative study indicated that social interactions between individuals and other people were at times crucial in the trigger, connection, and follow-up stages in participant examples. Study 4 confirmed a relationship between extraversion and serendipity in general, but its relationship was relatively weak and was not found to extend to serendipity within digital environments as hypothesized. Perhaps, like openness to experience, technology provides a democratizing effect, giving intraverts and extraverts alike the opportunity for serendipity within digital environments, regardless of how extraverted they may be in face-to-face interactions. Extraversion's weak relationship to serendipity buoys McBirnie and Urquhart's (2011) caution that social interaction is not a necessary precursor of serendipity. Though an inceasing number of social media tools are centre stage (e.g., Twitter) or play a supporting role (e.g., social recommendations) in digital environments, interactions within these digital environments may still be predominantly object-oriented rather than social in nature. People do interact with other people in digital environments, but they can interact with information and ideas presented by others without ever having to interact socially. Instead, perhaps situational factors and temporary states have more to say about serendipity than more stable personality traits. Perhaps for the work-related serendipity explored in this research, marked differences in personality are not significant because individuals, regardless of their level of extraversion or openness to experience, will have serendipitous experiences in digital environments.

Finally, the relationship between serendipity and locus of control – whether individuals attribute events to things outside or within their control – was evident in the investigative study, though unconfirmed in Study 4. In the investigative study (Study 1), the relationship between serendipity and intent and control appeared close and manifested itself through the unexpected thread element. With intent and control come expectation and when expectations are not met during any part of the process of serendipity (trigger, connections, follow-up, valuable outcome), the experience may be perceived as

serendipitous. It makes sense that those more likely to think events in their lives are controlled by external factors such as chance would indicate that serendipity occurred more frequently in the specific digital environment they chose to assess. But this was not the case. Study 1, however, indicated the complexity of both internal and external locus of control – the push and pull expressed by participants who attributed their serendipitous experiences to both internal and external forces. Perhaps this balanced view of events within the survey sample in Study 4 mirrored this inclination leading to the insignificant result.

7.3.2 Environments and Serendipity

Environment matters. The importance of environment has been demonstrated in creativity research in which the characteristics of an individual's environment impact their creative output (Oldham & Cummings, 1996). The importance of environment has been demonstrated in this thesis as well – environment influences the process of serendipity as well as the perception of the experience as serendipitous. The contexts in which serendipity occurs are innumerable and serendipity occurs during a wide range of activities and within a plethora of contexts (e.g., Foster & Ford, 2003; Pálsdóttir, 2011). However, this thesis pinpointed and confirmed that both the type and, more specifically, the characteristics of a digital environment influence serendipity.

While an open environment was identified as a characteristic of a serendipitous environment in the investigative study and re-imagined as a digital environment that enables exploration and tested in the final web-based study, this facet perhaps shared too much conceptual space with the other facets, which was why it did not emerge as a distinct factor in the exploratory factor analysis. Open environments and digital environments that enable exploration allow individuals the freedom to collect and share ideas, and at times have both the space and the tools to think outside the box. They allow *unimpeded and direct access*, *stopability*, *explorability,* and *multi-reachability* (Björneborn, 2008) and there is the potential to stumble upon triggers and explore connections. This conceptual overlap with triggers and connections may be why the enable exploration facet did not emerge as a distinct factor in Study 4. In the translation of an open environment to a digital environment that enables exploration, the emphasis

was placed on exploration. Perhaps future iterations of the SDE scale could include the more social aspects of the open environment. Social media shows a considerable amount of promise as a serendipitous digital environment and perhaps some of the characteristics of this digital environment should be more closely explored relative to serendipity. This thesis supports prior research that indicated that actively engaging with social media provides more opportunity for serendipity (Dantonio, Makri, & Blandford, 2012) so perhaps a facet that focuses more on the ability of a digital environment to allow information sharing might prove to support serendipity, though this too may be confounded with the trigger-rich and enables connections facets.

Of the remaining four proposed facets of a serendipitous digital environment – highlights triggers, trigger-rich, enables connections, and leads to the unexpected – only one did not share a significant relationship with serendipity in specific digital environments. The ability of a digital environment such as a website to highlight triggers failed to predict the frequency of serendipity in that website. Why won't pointing out interesting and useful information contained in a website or an intranet support serendipity? Highlighting triggers enables individuals to *notice*. Through the investigative study, face-to-face communication, visual saliency, noise, and emotion were identified as ways in which triggers were highlighted, bringing our focus of attention to triggers that we may not have otherwise noticed. Features of the environment, whether digital or physical, may be designed to catch the user's attention, drawing the user to interesting and unexpected content through visual cues (Björneborn, 2008). Highlighting triggers through curiosity-invoking display, striking contrasts, and pointers (Björneborn, 2008) prompts divergent behaviour, why not serendipity? Researchers have designed systems that highlight triggers in order to support serendipity; for example, Max, a web-based system that emails users links to websites with unexpected and interesting information (Campos & Figueiredo, 2002), and Mitsikeru, an ambient intelligence system that calls attention to interesting or surprising content (webpage links) relative to the user through visual cues (Beale, 2007). Perhaps people cannot help but notice information in digital environments. Maybe it is enough for digital environments to be trigger-rich and users will notice what is most salient to them, what catches their interest, not just what is most visually salient (McCay-Peet, Lalmas, & Navalpakam, 2012). Perhaps digital environments that highlight

triggers support divergent behaviour and information discovery, but not the more complex phenomenon of serendipity. Understanding how users interpret this facet in future studies may help to better understand better why highlights triggers underperformed in the final web-based study as a characteristic of a serendipitous digital environment.

While highlights triggers was not confirmed as a characteristic of a digital environment that supports serendipity, the other proposed trigger-related facet was: trigger-rich. The triggers of serendipity, the perceptual cues that serve as the catalyst for serendipity, must be present for an environment to have serendipity-inducing potential. Serendipity is unlikely to happen when an individual enters a bare room with little potential for interaction with information, ideas, objects, or phenomena. Instead, settings more conducive to serendipity include those designed to deliver information such as libraries, lecture rooms, as well as unfamiliar environments where new information can be found (Sun et al., 2011). In digital environments, the information encountered must be interesting and useful for it to have the potential of being serendipitous. Serendipity, it could be argued depends on the "textual affordances" (Toms, 2000) of the functions and features of digital environments – functions and features such as recommender systems, website menus, and article listings. Results of the final web-based study underline the importance of efforts that are being made in computer science to develop algorithms that ensure not only precision and accuracy but also the delivery of interesting and surprising recommendations (Oku, & Hattori, 2011). Just as "browsing depends on the ability of a piece of text to be recognized and examined" (Toms, 2000, p.424) – its textual affordances perceived – serendipity is reliant on an individual's interaction with text that can act as a trigger of serendipity due to its relationship to their interest space.

But trigger-rich environments are not necessarily enough to facilitate serendipity. Enables connections was identified as a characteristic of a serendipitous environment in the investigative study and further confirmed in the context of digital environments in the final web-based study. Sometimes individuals need to experience a juxtaposition of ideas or information that may enable the *new direction connections* identified in the investigative study. A serendipitous digital environment enables connections, something

that may be possible through visualization tools (e.g., Thudt, Hinrichs, & Carpendale, 2012) or social media sites that connect people to other people with interesting ideas and information. Connections was, as previously mentioned, an important element of the *process* of serendipity. Validation that a digital environment that enables connections facilitates serendipity further confirms the connection element's importance in the process.

The unexpected, as found in the investigative study, is woven through the process of serendipity. It may be present in one or more of the trigger, connection, follow-up, or valuable outcome stages and thus it is not surprising that an environment that leads to the unexpected supports serendipity. This is a very subjective quality of serendipity, but that does not prevent us from being able to provide opportunity for the unexpected. While we need to be cognizant of user expectations in digital environments, to follow the seventh golden rule of interface design – to support locus of control in which users feel in control over their interactions with technology (Shneiderman & Plaisant, 2009), we need to provide opportunity for surprise within that framework.

Finally, despite the conceptual overlap between serendipity and creativity, the creative environment as measured using the creative environment perceptions (CEP) questionnaire (Mayfield & Mayfield, 2010) was not a good predictor of serendipity. The investigative study (Study 1) indicated that the broader work environment has some influence on serendipity – an open environment – and the cognitive IIS&R framework (Ingwersen & Järvelin, 2005) further encourages exploration of the individual's broader context in relation to the individual and their systemic context (information objects, interface, and information technology). However, while the dimensions of creative environment perceptions appear to align with what has been found relative to a serendipitous environment – creativity support, a lack of creativity blocks, and work characteristics such as flexibility – perhaps another measure, more specifically designed with the broader serendipitous digital environment needs to be developed to test that relationship.

Figure 6 illustrates the relationships between serendipity and the significant characteristics of a digital environment that were identified in the final web-based study – leads to the unexpected, enables connections, and trigger-rich.

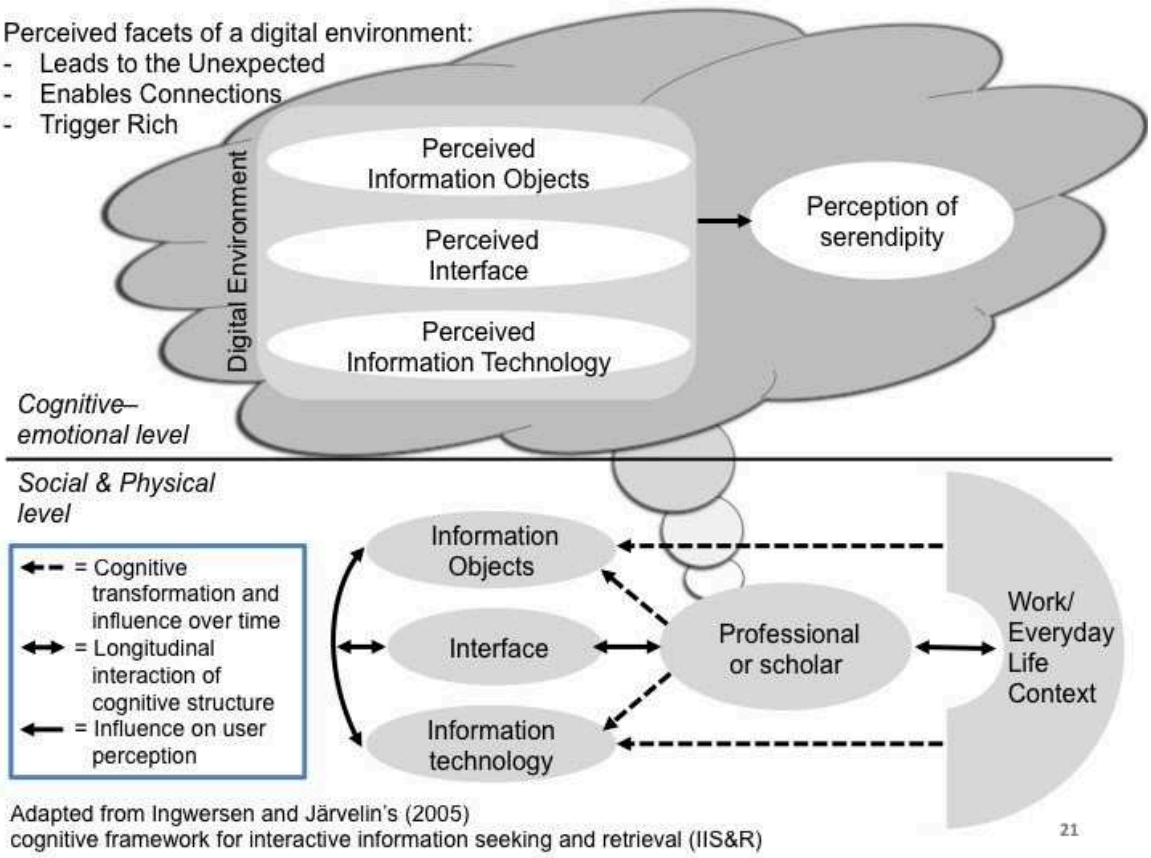

Figure 6 Relationships between perceived characteristics of a digital environment and perceived serendipity in a digital environment mapped onto Ingwersen and Järvelin's (2005) cognitive framework for IIS&R (adapted from Figure 6.9, p. 278 in Ingwersen & Järvelin, 2005).

In Figure 6 these relationships are mapped onto Ingwersen and Järvelin's (2005) cognitive framework for cognitive IIS&R in which they illustrate both the social and physical level of IIS&R as well as the perceived cognitive-emotional level of IIS&R. Due to the level of detail of the SDE scale, it is not possible to indicate which characteristics are most associated with the three components of the digital environment – information objects, information technology, and interface. For example, while leads to the unexpected was identified as a significant characteristic of a serendipitous environment, the unexpected factor may be attributable to the content within a digital environment (information objects), the algorithms that display unexpected results (information technology), or the features that allow users to interact with the information objects and information technology (interface).

Perceptions of digital environments develop over time. Perceptions of how well a digital environment facilitates serendipity are based on experiences within that environment and the characteristics of that environment associated with those experiences. More specifically, an environment that leads to the unexpected, is trigger-rich, and enables connections will not be considered serendipitous if some positive outcome is not perceived – how users perceive these experiences with a digital environment impact their work and everyday life context. This was also confirmed through results in Study 4 that indicated that serendipity is more likely to occur in some types of environments than others – one could argue that this is due to the differences among types of digital environments relative to their information objects, interfaces, and information technology among types of digital environments.

7.4 Summary

This chapter summarized and discussed the findings of this PhD research through two main themes relative to serendipity: individual differences and environments. The findings paint a picture of work-related serendipity, what influences it and how it may be facilitated in digital environments. While the results bolster findings of previous qualitative studies that point to the importance of individual differences in serendipity, still no strong evidence has emerged that openness to experience influences serendipity, a quality that is frequently mentioned in association with serendipity. While extraversion does share a relationship with serendipity, it is relatively weak in relation to serendipity in general and has no apparent influence on serendipity in digital environments. It seems more likely that an investigation of more situational factors relative to the individual – states of unfocussed attention, for example, may provide a deeper understanding of how and why serendipity occurs.

While the role of the broader environment in serendipity was supported in Study 1, just what form that support takes is unclear – the results suggest that the qualities of a creative work environment as measured using the creative environment perceptions questionnaire (Mayfield & Mayfield, 2010) do not influence serendipity. However, results do indicate that serendipity occurs more frequently in some digital environments than others, underlining the importance of the environment in serendipity. Furthermore, assessing the

SDE scale provided valuable insight into what characteristics of digital environments facilitate serendipity. While computer technology already exists to support the facets identified in this research and tools and functions have been developed with these facets in mind to support serendipity, the results from this research indicate that at least one – highlights triggers – does not influence serendipity. Instead, if we are to direct attention toward the development of digital environments that support serendipity, the focus should be on ensuring they are trigger-rich, enable connections, and lead to the unexpected. By zeroing in on specific characteristics of a potentially serendipitous digital environment, I believe this brings us closer to understanding what features and functions in a digital environment will support work-related serendipity and augments our understanding of serendipity within the cognitive IIS&R framework.

CHAPTER 8. CONCLUSION

The contributions of my PhD research, its limitations, and an outline of future research directions are discussed in this chapter.

8.1 Overview

This thesis examined the phenomenon of work-related serendipity – a phenomenon that has an impact on the individual as well as a reverberating effect felt across fields of study, organizations, and communities. The research contributes to a deeper understanding of serendipity, what influences it, and what supports serendipity in digital environments. The research also places the perception of serendipity and what influences it within the cognitive-emotional level of the theoretical framework of cognitive IIS&R (Ingwersen & Järvelin, 2005) and offers a tool to measure how well a digital environment supports serendipity.

8.2 Contributions

8.2.1 Models and Frameworks

In Chapter 4, a 4-stage model of the process of serendipity was presented. The model makes a contribution to the research through its confirmation of other recently developed serendipity models (Cunha, 2005; Makri & Blandford, 2012a; McCay-Peet & Toms, 2010; Rubin et al., 2011; Sun et al., 2011). The model also makes a contribution through its novel conceptualization of the unexpected thread. Unlike previous models, this model isolates the main elements, separating the unexpected aspect from the other four elements of the process of serendipity. The "unexpected thread" in the model may be woven through one or more of the elements rather than selectively and permanently coupling unexpected with the connections made or outcomes. This thread better reflects serendipity that is of both the "arrivals at unexpected destinations" (Koestler, 1964, p. 145) and "arrivals at the right destination by the wrong boat" (p. 145) kind. Sometimes the connections are unexpected, sometimes the outcomes are unexpected, and sometimes some other part of the experience is unexpected. The model also separated the individual differences and situational and environmental factors that may influence the process from its main elements to allow us to test these factors. What potentially *causes* or *influences* serendipity has been intimately tied to its very definition. While the inclusion of what

influences serendipity in its models is important, isolating the main elements of the process of serendipity from what influences the process helps us pinpoint factors that we can test.

Another contribution this thesis makes relative to research on the process of serendipity is that the three facets of a serendipitous digital environment that were confirmed in the final web-based study – *trigger*-rich, enables *connections*, and leads to the *unexpected* – also help to confirm the model of the process of serendipity. Each of those proposed facets of the serendipitous digital environment support a key element of the process of serendipity: *trigger*, *connections*, and *unexpected* thread. The other two elements, valuable outcome and follow-up, are also supported through the three facets; supports for triggers and connections facilitate follow-up and allow the individual to reach valuable outcomes.

Finally, another contribution this thesis makes with respect to models and frameworks is the integration of serendipity into the cognitive IIS&R framework (Ingwersen & Järvelin, 2005). The model (Figure 6, section 7.3.3) integrates serendipity, formerly missing from the IIS&R framework due to its emphasis on intentional information seeking and retrieval. It offers a new perspective on IIS&R by focussing on the users' perceptions of serendipity as they relate to the digital environment that is comprised of three of the five main components of the framework (interface, information technology, and information objects). There is an increasing degree of interest in how we may develop digital environments to support serendipity or at the very least remove barriers to serendipity, but research to date has primarily focused on information technology (e.g., algorithms of recommender systems). This research suggests the importance of extending research to include the entire scope of the digital environment, underlines the value of this IIS&R framework in the development of digital environments that support serendipity, and suggests directions for future research.

8.2.2 What Influences Serendipity

The two points of contention often embedded in the very definition of serendipity – the notion of intent and what causes serendipity – are deeply entwined. Serendipity is both within and outside the control of the individual. Using established psychometric tests,

prior research has assessed how personality influences incidental information encountering (Heinström, 2006) and how locus of control of behaviour influences perceptions of chance events (Bright, Pryor, & Harpham, 2005; Bright, Pryor, Chan, Rijanto, 2009; Hirschi, 2010). However, this PhD research makes a contribution by being the first to test how individual differences influence *serendipity* in a large, web-based study. This research also supports prior research that suggests that the prepared mind has a significant role to play in serendipity as well as temporary states and situational factors that may mimic individual differences such as openness to experience. While these factors were not tested in the final web-based study (Chapter 6), they merit further research.

Moreover, while research to date that has outlined how serendipity may be supported in digital environments based on qualitative studies, this is the first research to go a step further and test whether characteristics of digital environments believed to support serendipity actually do influence serendipity. This important step has ramifications for researchers and developers interested in developing, augmenting, and testing digital environments with a goal of improving users' opportunity for serendipity. While the connection between serendipity and the environment has been pointed out before (e.g., Björneborn, 2008), this research provides clear evidence of this relationship and suggests that designing digital environments to support serendipity would be a fruitful endeavour. These findings also suggest implications on how we might approach support for serendipity in digital environments. The facets of the serendipitous digital environment embedded in the SDE could be used as heuristics in the development of features and functions of digital environments to support serendipity. The take-away for designers is that a *serendipitous* digital environment should strive to be trigger-rich, enable connections, and lead to the unexpected. Highlighting triggers, while not significantly detracting from the serendipitousness of a digital environment, does not appear to influence the perceptions of serendipity, though future iterations of this research may lead to the reconceptualization and validation of this factor.

8.2.3 Measures

This study was novel in that it was the first to develop and validate a measure of the serendipitous digital environment. Due to the subjective nature of serendipity itself, self-reporting is an appropriate approach for the evaluation of the serendipitous digital environment; after all, the concepts of *unexpected* and *valuable* contained in the definition of serendipity are *relative* to the individual. While the SDE scale, like all scales at this stage in their development, needs further testing, it is a significant first step toward providing a useful tool to researchers and developers wishing to test whether the functions or features they are developing make a significant difference to serendipity.

8.3 Limitations

A number of limitations of this work primarily relate to participant memory, participant samples, conceptualization of the SDE, subjectivity, study bias, and validity.

Participant memory

It is challenging to collect data on serendipity; even information encountering, defined by specific, observable behaviours, is difficult to capture *in situ* (Erdelez, 2004). Both the first and final studies were reliant on participant memories. While participants' memories of serendipity in the investigative study (Chapter 4) were often quite detailed, it is impossible to know to what degree these memories may have changed over time with each retelling or what may have been forgotten. The final web-based study (Chapter 6) asked participants to recall their experience in a specific digital environment when responding to the SDE scale. Thus, there was a reliance on participants' ability to recall and the recency of these experiences may have influenced responses.

Participant samples

While 12 participants are considered a sufficient number in a qualitative study in which repetition of themes becomes apparent, more participants in the investigative study (Chapter 4) may have changed the nature of the findings and may have, for example, led to deeper findings relating to the delay that sometimes occurs when making connections. Findings as well may have been different had the focus been entirely on workers from a single field rather than the diversity that was sought in this research. A diversity of participants whose common connection was their work-related serendipity at this stage,

however, allowed for a continuation of this diversity in the final study – a study that required a significantly larger numbers of participants. Obtaining enough participants for the final web-based study would have been more difficult to meet if the focus was on a single domain or field. A large sample of participants helps ensure item means are not significantly influenced by error (DeVellis, 2003), but there is no consensus on how many participants are enough. While 353 participated in the final web-based study, a considerable loss of data brought the sample size down to 289. This loss was primarily due to missing responses spread fairly evenly over the variables. While Nunnally (1978, in DeVellis, 2003, p. 88) suggested 300 is a sufficient sample size, DeVellis noted that participant number is really dependent on the quantity of the items in the pool. MacKenzie et al. (2011, p. 310) observed that recommended sample sizes tend to range from 100 to 500 and the ratio of participants to items ranges from 3:1 to 10:1. I reduced the number of items prior to conducting exploratory analysis from 37 to 24 (see section 6.3.) as a preliminary step to hone the questionnaire and increase the ratio of participants to items to approximately 12:1, but sample size may still be considered by some to be a limitation of this research.

Conceptualization

Another potential limitation of this research was the conceptual leap that was made between the serendipitous environment in the investigative study and the development of a serendipitous *digital* environment scale. While some of the examples described by participants had a digital component, the majority of the examples were rooted in non-digital environments. Had examples of work-related serendipity in strictly digital environments been collected perhaps different facets of a serendipitous digital environment would have been identified; however, gaining a holistic understanding serendipity, regardless of location, was deemed more important in the beginning phase of this research. Furthermore, in retrospect, recruiting just twelve participants with a good memory of an example of serendipity was challenge enough without stipulating a digital component.

Subjectivity

To reduce researcher subjectivity in the development of the SDE scale, both qualitative and quantitative approaches were taken (Chapter 5). But the expert review relied on the *opinions* of the participants, however expert, and final decisions regarding the inclusion and revision of items, though guided by both the expert review and the ANOVA approach study, were my own. A different researcher may have developed a different set of facets and items. Due to the stage of development of the SDE scale, however, it is anticipated that more facets will be developed and items revised in future study iterations.

Study bias

The final study (Chapter 6), like the ANOVA approach study (section 5.3.4) was web-based. This allowed for the collection of a large amount of data in a relatively short period of time and with minimal cost. Web-based studies may be biased due to participant self-selection – nonresponse bias (Cook, Heath, & Thompson, 2000; Sax, Gilmartin, & Bryant, 2003). There was a range of age groups, however, in the final web-based study and a good proportion of both workers and students. In both web-based studies, the majority of participants were female (approximately 7:3). This imbalance by gender may introduce bias into the results; however, differences by gender were checked and none were found.

Validity

The construct validity of the SDE scale was tested using the serendipity questionnaire developed in Chapter 5, which did not undergo the same tests for content validity as the SDE scale or its own tests of construct validity prior to its use in Study 4. Validating direct measures of serendipity is particularly challenging given the difficulty of capturing serendipity *in situ*. While responses to the serendipity questionnaire reflect individuals' *perceptions* of the frequency of serendipity through both the use of questionnaire items that use the word *serendipity* and those that avoid the use of the word through the application of definition-based items, these direct measures would benefit from validation through means such as observational or diary studies.

8.4 Future Work

Despite research indicating serendipity's significance across a number of fields (e.g., Foster & Ford, 2003; McBirnie, 2008) and the pervasive and persuasive anecdotal documentation of its importance (e.g., Merton, 1957; Roberts, 1989), research into how serendipity may be facilitated has only just begun. While this thesis adds to the growing body of research examining how serendipity unfolds and how it may be facilitated, measures developed in this research must be further validated through future studies, new measures need to be developed, and we need to continue to build on theory.

8.4.1 Validation of Measures

The development of a questionnaire is a lengthy process, requiring many stages for its conceptualization, development, evaluation, refinement, validation, and to understand its relationship to other constructs (MacKenzie, et al., 2011). This disseration has laid a foundation for the development of the SDE scale, but more studies are required to further test its validity and experimentally manipulate the construct of the serendipitous digital environment. For example, does manipulating how well a digital environment enables connections by including a visualization function in one test system and not in another influence responses to the SDE? A study that first identifies what features, functions, or experiences individuals associate with the facets (and items) of the SDE may be a necessary preliminary step before designing such an experiment. As well, while highlights triggers was not a good predictor of serendipity, understanding what participants associate with the items of the highlights triggers facet and what if any associations they perceive between highlights triggers and serendipity in a digital environment may help in the redevelopment and possible validation of that facet in future studies.

8.4.2 Development of New Measures

Research has traditionally used *frequency* as a measure of serendipity and its related constructs (Eredelez, 1995; Heinström, 2006; Pálsdóttir, 2010) (see section 5.5). For example, Eredelez (1995) asked participants, "Describe *how often* and when do you usually experience bumping into useful information" (p. 161), while Heinström (2006) asked participants to respond on a scale to statements such as "*Sometimes* I come across

information even though I am not consciously looking for it" (p. 584). My research has similarly employed this self-report, occurence rate-type approach to measure serendipity, using items such as “I experience serendipity that has an impact on my everyday life” on a 5-point scale ranging from never to very frequently. Frequency is a useful approach to measurement because it has the potential to be gathered through both self-reports and, at least at the level of information encountering (Erdelez, 2004), observation. But other approaches to measurement need to be developed because frequency may not fully capture the *quality* of serendipity. For example, a user may report experiencing serendipity frequently in one digital environment versus infrequently in another, though the latter may lead to far-reaching valuable outcomes while the former less consequential. For example, Bogers and Björneborn (2013) describe “micro-serendipity” or micro-occurences of serendipity, meaningful coincidences that people describe as serendipity. Subsequently, we may not be able to adequately assess the relationship between serendipity and some factors of the environment and the individual soley using frequency.

For example, while no relationship was found in this research between serendipty – as measured by perceived *frequency* – and openness to experience, perhaps instead there is a relationship between openness to experience and the *level of impact* of serendipity – the perceived degree of importance it has to the outcome to a community, organization, or the world. In creativity research, different measures of creative output, assessments by experts, for example, have been developed – similar types of measures could possibly be developed in serendipity research. Makri and Blandford (2012b) have developed a framework of serendipity that could potentially be adapted as a self-report measurement tool. Their framework asks participants about specific examples of serendipity and has them rate how unexpected the circumstance, how insightful the connection made, and how valuable the outcome was on a 3-point scale of not at all, somewhat, and very. Developing different approaches to measurement will help us triangulate research findings and further develop theory relative to serendipity.

8.4.3 Theory Building

Developing other measures of serendipity is critical to theory building but so too is the exploration of other factors linked to serendipity. While this research examined locus of

control of behaviour, openness to experience, and extraversion, many individual differences have yet to be explored in relation to serendipity. While openness to experience (Lee & Ashton, 2004) covers some of the qualities of a creative personality, perhaps other measures that specifically tap the characteristics of curiosity and creativity could be explored. I did not examine the prepared mind in the larger web-based study – this may be a factor to explore in future research, though the challenge will be to develop a good measure of the prepared mind. Relative to the cognitive IIS&R model, more research is needed to link the perceptual findings from the cognitive-emotional level of the framework to the physical/social level. More research is also needed to examine the relationship between the broader social environment and serendipity. While no relationship between the creative work environment and serendipity were found in this research, other broad context factors could be explored and potentially integrated into the model.

Furthermore, the investigative study found that someone may have an experience that "checks all of the boxes" – there is a trigger, a connection, a valuable outcome, and there is something unexpected about the experience – and yet not necessarily consider the experience serendipitous. In the context of designing digital environments, does it matter whether users have experiences they consider serendipitous or is it enough that they reap the benefits of going through the motions of a serendipitous experience without reflecting on the experience as serendipitous? Perhaps simply designing digital environments to be serendipitous is enough, as users will reap the rewards that serendipity entails; in other words, users may not need to ascribe the term serendipitous to their interactions in a digital environment for them to want to keep coming back. I would argue that there is value in designing digital environments that support serendipity because the phenomenon provides a framework for developing digital environments that have the potential to facilitate unexpected and positive experiences. However, a study could examine whether how serendipitous users find digital environments has an influence on how valuable they think their experiences in these digital environments are – essentially examining the relationship between serendipity's valuable outcome element and the perception of serendipity.

8.4.4 Development of Heuristics

Understanding how perceptions relate specifically to digital environments will help to operationalize the facets, point to specific functions that support serendipity and support the development of heuristics for the design of serendipitous digital environments. Participants in the expert review (section 5.3.3) made comments regarding the vagueness of facet definitions. While I attempted to strike the right balance of specificity, future research will examine what individuals think of when responding to the items. For example, what features, tools, or experiences they envision when they read statements such as "I encounter the unexpected in [the digital environment]" (U2). Relative to the IIS&R framework (Figure 6), are participants responding based on their perceptions of the information objects, information technology, or features of the interface of a digital environment? Answering these questions will aid in the development of design heuristics.

8.5 Summary

Serendipity is a complex phenomenon that resides within a wide and contentious conceptual space. But its value to people, communities, and organizations is such that understanding how and why it unfolds is imperative as this knowledge promises to help in the development of environments to facilitate it. With a specific focus on the digital environments in which academics and professionals are so often immersed, the overall objective of this thesis was to examine how work-related serendipity unfolds and what aspects of the individual and the environment influence this process. But before the influences of serendipity could be explored, this thesis first had to identify what these influences may be and develop measures that could be used to confirm the influence of factors relating to the individual and the environment. Therefore, the main objective of this research was accomplished through three phases of mixed methods research.

The first phase of the research laid the groundwork through the conceptualization of serendipity through a review of the prior research as well as an investigative study in which 12 professionals and academics were interviewed about work-related serendipity. This led to the identification of both factors related to the individual and the environment to be explored in the third phase of this research. Before that could be accomplished, measures of both characteristics of digital environments hypothesized to facilitate

serendipity as well as serendipity itself had to be developed in the second phase of this research. The measure of the serendipitous digital environment (SDE), a self-report questionnaire comprised of five hypothesized facets of the SDE, was developed. The content validity of the SDE scale was assessed through two methods: an expert review by eight researchers with experience in serendipity-related constructs as well as a web-based study in which 107 university students assessed how well the items of the SDE scale reflected their hypothesized facets. Furthermore, a direct measure of serendipity was also developed – a self-report questionnaire to assess the frequency of serendipity in a specific digital environment, in digital environments in general, and in general. Phase 3 further honed and assessed the validity of the SDE scale through a web-based survey of 289 professionals, academics, and graduate students who frequently search for and monitor information as part of their work. Moreover, in this same study, the relationships between the characteristics and types of digital environments, individual differences, and serendipity were explored using both the SDE scale and serendipity questionnaire together with pre-existing questionnaires designed to measure openness to experience and extraversion (Lee & Ashton, 2004), locus of control of behaviour (Craig, et al., 1984), and creative environment perceptions (Mayfield & Mayfield, 2010).

Results indicate that type (e.g., work intranet versus social media) and characteristics of the digital environment have a strong relationship to serendipity. In particular a significant relationship was found between serendipity and digital environments that are perceived to lead to the unexpected, enable connections, and are trigger-rich. Another hypothesized characteristic of a serendipitous digital environment – highlights triggers -, however, shares no significant relationship to serendipity. While no relationships were found between serendipity and openness to experience and creative environment perceptions, a relationship was found between extraversion and serendipity in general.

This research made three main contributions:

1) Confirmed and augmented prior models of the process of serendipity and integrated an individual's perceptions of a serendipitous digital environment into the cognitive IIS&R framework (Ingwersen & Järvelin, 2005), a previously missing component of our understanding of information seeking and retrieval;

2) Identified the characteristics of a digital environment that have the potential to facilitate serendipity – and confirmed that environment matters and that we can in fact "design for serendipity;" and,

3) Developed and began the initial steps in the validation of the SDE scale, a means of measuring how well digital environments such as websites, search engines, social media sites, databases, and work intranets foster serendipity.

While the first and second contribute to our knowledge of information seeking, searching, and retrieval, the second and third provide both a source for design elements that may augment information systems to make them serendipity-inducing, and a tool for developers to assess the serendipitous nature of their systems. Furthermore, the methods outlined in this thesis may be used as a guide for researchers interested in developing their own measures of the perceptions of fuzzy concepts. Just as serendipity so often involves putting the pieces of a puzzle together to come to a novel understanding of a topic or the development of a new way of solving a problem, this research offers several pieces of the puzzle that will help further serendipity research and support the development of creative ideas in the work context.

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APPENDIX 1 DEFINITIONS OF SERENDIPITY-RELATED CONSTRUCTS

Term	Definition
Accidental information discovery	See *incidental information acquisition*
Chance encounter	"Serendipitous information retrieval occurs when a user with no a priori intentions interacts with a node of information and acquires useful information. We can say that the retrieval was triggered 'by chance' or a chance encounter. A chance encounter occurs at the point in human interaction with an information system when a human makes an accidental and often sagacious discovery" (Toms, 2000, np).
Everyday chance encounters	"Chance encounters with information, objects, or people that lead to fortuitous outcomes are an integral part of everyday information behaviour" (Rubin, et al., 2011). Also referred to as "accidental encounters"
Information encountering (IE)	"A specific type of OAI"; "an instance of accidental discovery of information during an active search for some other information" (Erdelez, 2005, p. 180)
Chance event	"Despite the different terminology and subtle definitional differences found in the literature, chance events generally relate to 'unplanned, accidental, or otherwise situational, unpredictable, or unintentional events or encounters that have an impact on career development and behavior' (Rojewski, 1999, p. 269)" (Bright, et al., 2005, p. 562).
Incidental exposure to news	While on the web, incidental exposure to news occurs when "people encounter current affairs information when they had not been actively seeking it" (Tewksbury, Weaver, & Maddex, 2001)
Incidental exposure to online news	Incidental exposure to online news is defined as "memorable experiences of accidental discovery of useful and interesting news when people engage in various activities online" (Yadamsuren & Erdelez, 2010).
Incidental information acquisition (IIA)	IIA is "synonymous with 'accidental information discovery,' suggesting that people find information unexpectedly as they engage in other activities. Some of this information they did not know they needed until they heard or read it" (Williamson, 1998, p. 24); Incidental (or serendipitous) information acquisition occurs when "acquiring (useful or interesting) information while not consciously looking for it" (Heinström, 2006, p. 580). NOTE: Heinström, unlike Williamson, *explicitly* includes "information retrieved while searching for another topic" (Heinström, 2006, p. 580).

Term	Definition
Incidental news exposure on the web	"This dissertation operationalizes incidental news exposure online as encountering news while going online for another purpose" (Lee, 2009, p. 36)
Incidental online news exposure	"News headlines are an almost constant feature of the most frequently visited sites on the Web, and there is some evidence that people encounter current affairs information when they had not been actively seeking it. Encounters of this sort may be called incidental exposure, and this may be an important contemporary avenue for citizen acquisition of current affairs information" (Tewksbury, et al., 2001, p. 534)
Non-directed\monitoring	"Non-directed monitoring involves serendipitously encountering and recognizing a source (e.g. seeing a father pushing a double baby carriage, finding a book sale) in an unlikely place, while not seeking information at all (chatting with acquaintances), or while monitoring information sources (such as reading the daily newspaper) with no intent other than to become generally informed" (McKenzie, 2003, pp. 26-27).
Opportunistic acquisition of information (OAI)	OAI is described as an experience in which users "find interesting and useful information without purposeful application of information searching skills and strategies." (Erdelez, 2004, p. 1013) Users were "not purposefully seeking that specific information" (Erdelez, 2004, p. 1014)
Opportunistic discovery of information (ODI)	Referring to ODI, "people often stumble upon interesting and useful information without performing an active search or while searching for a different topic entirely. In these situations, information is discovered unintentionally, fortuitously and unexpectedly, often resulting in a valuable outcome"; also, may happen during "everyday life" (Erdelez & Makri, 2011, np)
Serendipitous information encounters	Serendipity with the context of information seeking is "a phenomenon arising from both conditions and strategies – as both a purposive and a non-purposive component of information seeking and related knowledge acquisition" (Foster & Ford, 2003, p. 321). The nature of serendipitous information encounters is illustrated in Foster & Ford (2003, p. 334) in which there are two dimensions relating to the known/unknown location of the useful content as well as unanticipated/ anticipated nature of the relevant content.
Serendipitous information retrieval	"Serendipitous information retrieval occurs when a user with no a priori intentions interacts with a node of information and acquires useful information. We can say that the retrieval was triggered 'by chance' or a chance encounter" (Toms, 2000, np).
Serendipity in information seeking (SIS)	"SIS reflects the narrower confines of information seeking and refers to the specific activity of finding needed information while seeking different needed information" (McBirnie, 2008, p. 604)

APPENDIX 2 STUDY 1

Appendix 2.1 Recruitment Instrument

[This letter was sent via email directly to potential participants and to administrators to post via listservs].
Serendipity in Knowledge Work Study [subject line]

We are conducting a study to gain a better understanding of serendipity. Serendipity is defined as the art of making fortunate and unexpected discoveries by chance. We are seeking professionals and academics from a variety of fields who are willing to share serendipitous experiences they have had in the course of their knowledge work to participate in this study.

The study will start August 5, 2010 and continue through to October 15, 2010. Interviews will be conducted in person or by phone at your convenience. The interview, consisting of a series of short questions related to serendipity, will take 45-60 minutes of your time. With your permission, you may be asked brief follow-up questions via email which may take 5-10 minutes of your time, though no follow-up may be necessary. Your participation in this study is voluntary and will be kept confidential.

May I call you to set up a time to talk via phone to explain the study? The purpose of this conversation will be to determine whether or not you have an example of serendipity that we could discuss in the interview before planning a time and place for the interview (in-person or by phone). Your participation in this study would be greatly appreciated. Please e-mail me at mccay@dal.ca.

Thank you,
Lori McCay-Peet, Principal Investigator
PhD student, Interdisciplinary Studies
Dr. Elaine Toms, Supervisor
Canada Research Chair in Management Informatics
Faculty of Management

Faculty of Management
Dalhousie University
6100 University Avenue, Halifax, NS B3H 3J5
hci@dal.ca; phone: 494-8392

Appendix 2.2 Screening Measures

[Participants were asked the following questions via telephone or email prior to setting an interview].

1. In this study, serendipity is defined as the art of making fortunate and unexpected discoveries by chance. Indicate which sentence best describes your experience with serendipity in relation to your work:

a) I don't think I have ever experienced serendipity.
b) I can recall one or two incidences of serendipity.
c) I can recall several incidences of serendipity.

2. Briefly describe one or two examples of serendipity that you have experienced in relation to your work (approx. 1-2 sentences for each).

3. Please indicate the degree of your memory surrounding the details of these serendipitous experiences (e.g., what you were doing and thinking at the time):

My memory of these serendipitous experiences is:

a) Limited
b) Good
c) Very good

Appendix 2.3 Interview Protocol

1. Domain/work tasks

1.1. Could you describe for me the type of work that you do?

Follow-up questions to guide the conversation:

1.1.1 How long have you been working in this field?

1.1.2 Have you worked in any other fields? If so, how have these previous work experiences influenced your current work?

1.2 Could you describe your typical work tasks or projects?

Follow-up questions to guide the conversation:

1.2.1 Where do the ideas for projects come from?

1.2.2 Would you say that you primarily work independently or collaboratively?

1.2.3 Do you typically rely on technology to complete your project?

1.2.4 Do you ever draw on previous work when you start a new project? Or is each project a separate entity?

2. Defining serendipity

2.1 In a moment I am going to ask you to think of a specific time in your work life when you experienced serendipity, but first I want to discuss the meaning and definition of serendipity.

Serendipity is defined as the art of making fortunate and unexpected discoveries by chance.

It has also been defined more specifically as "the fairly common experience of observing an *unanticipated, anomalous and strategic datum* which becomes the occasion for developing a new theory or for extending an existing theory" (Merton, 1948, p. 506).

Would you agree with these definitions?

2.2 What would you describe as the key components or qualities of serendipity (e.g., unexpected, useful)?

3. Example of serendipity

3.1 Can you think of a specific time in your work life when you experienced serendipity?

Interview writes down key moments in sequence to use in follow-up questions. The following are follow-up questions to guide the conversation [Note: each question will be tailored to the example described by the participant. For example, "concept" will be replaced with the appropriate descriptor as indicated by the participant]:

3.1.1 Could you describe what you were working on at the time?

3.1.2 At what stage were you in the project you were working on at the time (e.g., idea generation, preparation, elaboration, analysis and writing, dissemination)?

3.1.3 What was your understanding of this concept(s) before this time?

3.1.4 What was it that initially caught your attention (e.g., textual passage, a visual, conversation)?

3.1.5 How did it catch your attention (e.g., did someone initially bring it to your attention)?

3.1.6 Why do you think it caught your attention at that particular time?

3.1.7 Do you remember what you were thinking when you saw it?

3.1.8 How would you describe what you felt when you came across this concept (e.g., surprise, shock, relief).

3.1.9 Was this a concept with which you were previously familiar or was it new to you (i.e., had you noticed the concept before but perhaps ignored it)

3.1.10 If you were familiar with the concept, what made you stop and pay attention to it at this time? Had you paid attention much attention to the concept before?
3.1.11 If you were unfamiliar with the concept, what made you stop and pay attention to the concept at this time?
3.1.12 What associations, if any, did you make between this concept and your previously held beliefs, notions and knowledge? How did you see it connecting with your work?
3.1.13 Did you stop what you were doing to pursue this new concept or did you come back to it later?
3.1.14 If you stopped what you were doing, what was it that you did (e.g., thought about it, ask someone questions, research independently)?
3.1.15 If you came back to it later, how did you do this (e.g., relied on memory, made a note, reminded by someone/something else)?
3.1.16 How were you able to make sense of this concept? For example, did you need to do further research to confirm your understanding or did you need time to think it through logically?
3.1.17 What was the product or outcome of this serendipitous discovery?
3.1.18 How would you describe the value of this serendipitous discovery?
3.1.19 Were there any barriers to your serendipitous discovery? How did you overcome these?
3.1.20 How long do you think it was between the time you were first exposed to this concept to when you actively took notice of the concept?
3.1.21 How long do you think it was between the time you actively took notice of the concept and when you disseminated the product of this serendipitous discovery?

3.2 Can you think of another specific time in your work life when you experienced serendipity? [NOTE: only ask if there appears to be time]
[*Note: if previous example give is not related to a serendipitous experience in an information system ask:* In particular, have you ever experienced serendipity while using your computer to (e.g., searching the internet)? If not, do you have any other examples of serendipity?]
[If yes, repeat questions 3.1 and 3.2; if no, proceed to next section]

4. Serendipity in general

4.1 Thinking about your own experience with serendipity in general, is there a common environment in which it occurs or common conditions?
Follow-up questions to guide the conversation:
4.1.1 Is it a matter of right time and right place?
4.1.2 Is social networking a common factor – do colleagues spark serendipity?
4.1.3 Do you find you are actively working on something (e.g., analyzing, research) when serendipity occurs?
4.1.4 Does serendipity happen during periods of great activity or during a lull in activity?

4.2 How would you describe the product of serendipitous discovery in relation to your field of work (e.g., new to you or new to human history)?
4.3 How would you describe serendipity in relation to your field of work? Is it an important component? Is serendipity common?

Appendix 2.4 Consent

Serendipity in Knowledge Work

Principal Investigator and Contact Person: Lori McCay-Peet
PhD student, Interdisciplinary Studies

Supervisor: Dr. Elaine Toms
Canada Research Chair in Management Informatics
iLab, Faculty of Management
Dalhousie University
6100 University Avenue, Halifax, NS B3H 3J5
hci@dal.ca; phone: 494-8392

Date: _____
Participant ID: _____

Introduction

Thank-you for your interest in this research study. Participation is voluntary. You may withdraw from participation at any time, and you may decline to answer any question. The study is described below. Please discuss any questions you have about this study with the researcher.

Purpose

The purpose of this study is to understand serendipity in knowledge work. The study will consist of individual interviews with approximately 12 adult participants from a variety of fields in the sciences, social sciences, and humanities who have experienced serendipity in the course of their work.

What you will be asked to do

After signing this consent form, you will be asked questions regarding serendipity in your work. The interview is estimated to take 45-60 minutes. Your answers to interview questions will be recorded via a digital audio recorder and some notes may be hand recorded by the researcher. Following the interview you will be asked to indicate whether or not you wish to be contacted via email with follow up questions that may arise from our analysis.

Risks/Benefits

The risks of participating are comparable to everyday experience. Participating in the study may not benefit you directly, but we might learn about serendipity that may benefit people in your field.

Compensation

No compensation will be provided.

Confidentiality & Anonymity

Following the interview you will be given the opportunity to indicate whether or not the specific examples of serendipity that you discuss in this interview may be used in presentations and publications emanating from this study and whether or not you wish your name to be used in relation to these examples. All other results of this study will be treated confidentially and reported without any reference to you specifically. The interview will be transcribed by a third party transcription service. A non-disclosure/confidentiality agreement has been signed by this company to maintain

confidentiality. We may directly quote your responses to questions, but no identifying information will be included. The data from this study will be compared with data collected in the past on a similar study. Anonymised results of the study will be posted on the iLab at Dalhousie website [TBD].

Data Retention

All research data will be kept in a secure location under confidentiality (in accordance with Dalhousie University policy) for 5 years after publication.

In the event that you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Patricia Lindley, Director of Dalhousie University's Office of Human Research Ethics Administration: (902) 494-1462.

"I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in the study. However, I understand that my participation is voluntary and that I am free to withdraw from the study at any time."

Participant

Name: _____

Signature: _____

Date: _____

Researcher

Name: _____

Signature: _____

Date: _____

Appendix 2.5 Demographics Questionnaire

Date: _____
Participant ID: _____

1. What diplomas/degrees have you ***completed***? Check all that apply and specify discipline where indicated.

   ___ High school

   ___ College diploma – *specify discipline*:_____

   ___ Undergraduate degree – *specify discipline*:_____

   ___ Doctoral degree – *specify discipline*: _____

   ___ Graduate degree – *specify discipline*: _____

   ___ Professional degree (e.g., MD) - *specify*: _____

   ___ Other - *specify*: _____

2. What diplomas/degrees are you ***currently*** pursuing, if any? Check all that apply and specify discipline where indicated.

   ___ High school

   ___ College diploma – *specify discipline*: _____

   ___ Undergraduate degree – *specify discipline*: _____

   ___ Graduate degree – *specify discipline*: _____

   ___ Doctoral degree – *specify discipline*: _____

   ___ Professional degree (e.g., MD) - *specify*: _____

   ___ Other - *specify*: _____

3. What is your gender?
   ___ Male

   ___ Female

   ___ Prefer not to respond

4. What is your approximate age?

   ___ 18-20 ___ 46-50

   ___ 21-25 ___ 51-55

   ___ 26-30 ___ 56-60

   ___ 31-35 ___ 61-65

   ___ 36-40 ___ 66+

   ___ 41-45

Appendix 2.6 Follow-Up Consent

Serendipity in Knowledge Work

Principal Investigator and Contact Person: Lori McCay-Peet
PhD student, Interdisciplinary Studies

Supervisor: Dr. Elaine Toms
Canada Research Chair in Management Informatics
iLab, Faculty of Management
Dalhousie University
6100 University Avenue, Halifax, NS B3H 3J5
hci@dal.ca; phone: 494-8392

Date: _____
Participant ID: _____

1. Use of your examples of serendipity

1.1 Please indicate whether you agree with the following:

I agree that the examples of serendipity discussed in this interview may be described in publications and presentations emanating from this study.
____ Yes
____ No

1.2 If you answered yes to the previous question, please indicate whether you agree with the following:
I agree that my name can be used in reference to the examples.
____ Yes
____ No

2. May we contact you after the interview via email for possible follow-up questions? It is anticipated that you would be able to respond in a paragraph and would take 5-10 minutes of your time. No follow-up may be necessary.
____ Yes
____ No

Participant Comments:

Participant
Name: _____
Signature: _____
Date: _____

Researcher
Name: _____
Signature: _____
Date: _____

APPENDIX 3 STUDY 2

Appendix 3.1 Recruitment Instrument

Email subject line: "Expert review of the serendipitous digital environment scale"
[Researcher],

We are identifying the characteristics of digital environments that foster serendipity. These characteristics will be used in the development of an instrument to measure how well digital environments such as information systems, websites, and applications foster or support serendipity. We need 5-8 reviewers who have expertise in serendipity (or related constructs) as an area of research. As one of those experts, we are requesting your assistance.

Do you have time in the next two weeks to review the preliminary facets of the serendipitous digital environment that were identified in prior research and assess the items that have been developed to measure these facets? We anticipate that the review will take approximately 30-60 minutes of your time. If you are willing, your contribution will be acknowledged in Lori McCay-Peet's thesis.

If you have time to do this, please respond and we will send you a consent form and the questionnaire to complete.

Your participation in this study is voluntary and you may withdraw at any time.

If you have any questions, please contact Lori McCay-Peet at Dalhousie University: mccay@dal.ca

Principal investigator:
Lori McCay-Peet (MLIS)
PhD Candidate, Interdisciplinary Studies, Dalhousie University
Halifax, Nova Scotia, Canada

Co-investigators:
Dr. Elaine G. Toms
Information School, The University of Sheffield
Sheffield, United Kingdom

Dr. Bertrum MacDonald
School of Information Management, Dalhousie University
Halifax, Nova Scotia, Canada

Appendix 3.2 Consent Form and Instrument

Consent Form

Principal investigator:
Lori McCay-Peet (MLIS)
PhD Candidate, Interdisciplinary Studies, Dalhousie University
Halifax, Nova Scotia, Canada

Co-investigators:
Dr. Elaine G. Toms
Information School, The University of Sheffield
Sheffield, United Kingdom

Dr. Bertrum MacDonald
School of Information Management, Dalhousie University
Halifax, Nova Scotia, Canada

Introduction

Thank-you for your interest in this research study. This review is part of a larger study investigating serendipity. We are identifying the characteristics of digital environments that foster serendipity. These characteristics will be used in the development of an instrument to measure how well digital environments such as information systems, websites, and applications foster or support serendipity. The Expert Review will consist of 5-8 reviewers who have expertise in serendipity (or related constructs) as an area of research. If you are willing, your contribution will be acknowledged in Lori McCay-Peet's thesis.

Participation is voluntary. You may withdraw from participation at any time, and you may decline to answer any question. The study is described below. Please feel free to contact the principal investigator should you have any questions.

Purpose

The purpose of the expert review is to maximize the validity of the pool of items developed for the serendipitous digital environment scale before they are assessed in a larger web-based study.

What you will be asked to do

1) Review and comment on the definitions of the five facets of the serendipitous digital environment together with statements or items developed for each of the facets. The review is estimated to take 30-60 minutes to complete. You are asked to record all responses within this document. You may decline to answer any question.

2) Return the completed review via email to the principal investigator.

Risks/Benefits
It is anticipated that no risk greater than that encountered in everyday life will be experienced. Participating in the study is not anticipated to benefit you directly. However, your participation will help in the development of a tool that will be of use to the research community in which you are involved.

Compensation
No compensation will be provided.

Confidentiality & Anonymity
If you are willing, your contribution will be acknowledged in Lori McCay-Peet's thesis. You will have an opportunity to indicate whether or not you would like your contribution acknowledged in the final question of the questionnaire. No direct quotes will be used in any reporting.

Data Retention
All research data will be kept in a secure location under confidentiality (in accordance with Dalhousie University policy) for 5 years after publication.

In the event that you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director of Dalhousie University's Office of Human Research Ethics Administration: (902) 494-1462.

I have read the explanation about this study. I hereby consent to take part in this study; however, I realize that my participation is voluntary and that I am free to withdraw from the study at any time.

1. Introduction
Both the existence and value of serendipity is widely recognized in a multitude of domains of human inquiry and experience. Research suggests, however, that some people may experience serendipity more frequently than others and some environments may be more conducive to serendipity. Digital environments, for example, are not neutral with respect to serendipity – a search system designed purely for accuracy and precision may not provide an environment as conducive to serendipity as a system that supports browsing, provides a level of personalization, or makes tangentially relevant results visible to the user. But how can we ascertain how well *specific* digital environments support serendipity? While there are reliable psychometric instruments available to measure such personality traits as *openness to experience*, there is no valid instrument to measure the serendipitous digital environment making it difficult to explore relationships between psychological and environmental factors impacting the experience of serendipity. This study makes a step toward the development of an instrument to measure the serendipitous digital environment.

1.1 What we have done

Based on findings from interviews with academics and professionals on their work-related experience of serendipity as well as an extensive review of prior research on serendipity across multiple disciplines, a working definition of serendipity has been developed:

> an unexpected experience with respect to time, place, source or outcome, prompted by an individual's *valuable* interaction with ideas, information, objects, or phenomena.

In turn, a working definition of a serendipitous digital environment has been developed:

> *a database, information system, website, application, or other system reliant on computer technology which facilitates serendipity by supporting exploration, enabling connections, being trigger-rich, highlighting triggers, and leading users to the unexpected.*

Thus far, five facets of the serendipitous digital environment have been identified: 1) *Enables Exploration,* 2) *Trigger-rich,* 3) *Enables connections,* 4) *Highlights triggers*, and 5) *Leads to the unexpected*. These facets each represent a characteristic of a digital environment that fosters serendipity. Using these five facets, items for a scalar instrument – a questionnaire – designed to measure serendipity have been generated. Each of the facets are defined and described in greater detail in the sections that follow and items relating to each facet are listed.

1.2 What we would like you to do

We would like you to review the serendipitous digital environment instrument on two levels:

> **1) Facets:** We have identified five *potential* facets of the serendipitous digital environment but are these facets sufficient? Are there more or perhaps less than five facets? Do the facets adequately capture the abstract concept of the serendipitous digital environment? Are their definitions clear?
>
> **2) Items:** Based on the five facets, we have developed scalar items designed to capture a user's perception of how well a digital environment supports serendipity. Do these items align with the facets they are meant to capture? Are they clear? Can you suggest other items that would better capture the essence of the facets?

NOTE: We focus here on the environmental factors relative to the experience of serendipity. Subsequent studies are planned to explore relationships between psychological and environmental factors that facilitate serendipity.

Please read through the following sections. In each section instructions will be provided to help guide your review. Space for comments is provided throughout, however, feel free to treat this as a working document, making comments wherever and however you wish (e.g., track changes, comment function in Microsoft Word).

2. Facets

The five facets of the serendipitous digital environment identified through a review of prior research are each defined in the sections below in a single sentence together with a brief justification of each facet's inclusion. Please comment on, for example

- the appropriateness of the facet relative to the notion of the serendipitous digital environment
- the clarity of the definition and suggestions for improvement

Furthermore, we do not presume that these five facets definitively capture serendipitous digital environment. If you think we are missing a facet, please feel free to suggest facets.

2.1 Enables exploration

Definition: The digital environment supports the unimpeded examination of its information, ideas or resources. [Justification: This facet addresses the perceived accessibility of and inter-actability with the digital environment's content. For a database, information system, website, or application to facilitate serendipity, it must allow users free and easy access to its resources. A digital environment that is easy to explore or examine reduces barriers to information or resource discovery that in turn feeds the perception of the environment as conducive to serendipity.]
Comments (e.g., the appropriateness of the facet definition relative to the notion of the serendipitous digital environment; the clarity of the definition; and suggestions for improvement):

2.2 Trigger-rich

Definition: The digital environment is filled with a variety of information, ideas, or resources interesting and useful to the user. [Justification: This facet addresses the informational content of a digital environment relative to the user. For a database, information system, website, or application to facilitate serendipity, it must contain the type of content that is most likely to spark a serendipitous experience. Much of the content of the digital environment may not be valuable or only tangentially related to the user's area of research or work, but the digital environment must be perceived as containing nuggets of interesting and useful content for it to be perceived as an environment conducive to serendipity.]
Comments (e.g., the appropriateness of the facet definition relative to the notion of the serendipitous digital environment; the clarity of the definition; and suggestions for improvement):

2.3 Enables connections

Definition: The digital environment exposes users to combinations of information, ideas, or resources that make relationships between topics apparent. [Justification: This facet addresses the combinatorial, creative nature of serendipity that may be supported through appropriate interactive tools or presentation of information. For a database, information system, website, or application to facilitate serendipity, it must provide opportunity for users to see relationships between their own area of interest and the resources, information, and ideas contained in the digital environment.]
Comments (e.g., the appropriateness of the facet definition relative to the notion of the serendipitous digital environment; the clarity of the definition; and suggestions for improvement):

2.4 Highlights triggers

Definition: The digital environment actively points to or alerts users to interesting and useful information, ideas, or resources using visual, auditory, or tactile cues. [Justification: Screens are often visually very busy with images, moving objects, colour, and other features competing for the user's attention. Consequently, users often miss stumbling upon potentially useful and interesting information and resources because they are trying to focus on the task at hand or are otherwise occupied. For a database, information system, website, or application to facilitate serendipity, users must perceive that the digital environment calls attention to valuable information at just the right time, when the user is most receptive to it.]
Comments (e.g., the appropriateness of the facet definition relative to the notion of the serendipitous digital environment; the clarity of the definition; and suggestions for improvement):

2.5 Leads to the unexpected

Definition: The digital environment provides fertile ground for unanticipated or surprising interactions with information, ideas, or resources. [Justification: While definitions of serendipity often vary, some aspect of the unexpected is contained in each, whether is couched in terms such as surprise, chance, accident, or luck. For a database, information system, website, or application to facilitate serendipity, users must perceive that their interactions with the digital environment will provide opportunity for discoveries and unexpected revelations.]
Comments (e.g., the appropriateness of the facet definition relative to the notion of the serendipitous digital environment; the clarity of the definition; and suggestions for improvement):

6) Other Facet? (Are there facets of the digital environment that you think we are missing? Describe.)

7) Other Facet? (Are there facets of the digital environment that you think we are missing? Describe.)

General comments about the facets?

3. Items

For each of the preliminary five facets of the serendipitous digital environment, 7-10 items have been developed. These are short statements designed to capture the "essence" of each of the facets.

For example, for the facet "Enables exploration" one item may be

> "[The digital environment] supports browsing of its content"

When administering this questionnaire, researchers will be able to replace "[The digital environment]" with the specific website, application, or information system being tested. For example, the above statement may become:

> "Twitter supports browsing of its content""

Participants would be asked to rate their level of agreement to this and other statements on a 5-point scale [strongly disagree; disagree; neither agree nor disagree; agree; strongly agree].

The following **rules for scale item development** were followed (DeVellis, 2003):

- Avoid items that assess more than one characteristic
- Avoid items with which almost everyone or almost no one is likely to agree
- Avoid complex or compound sentences
- Keep language clear, simple, and direct
- Keep items short
- Maintain positive wording for all items

Instructions:
Please read the items outlined in the following sections. Spaces are provided so that you may, for example

- **comment on the appropriateness of the items in relation to facets**
- **identify items that you think break one of the rules for scale item development identified above**
- **suggest alternative wording of items**
- **propose new items**

3.1 Enables exploration

Definition: The digital environment supports the unimpeded examination of its information, ideas or resources.

	Proposed scalar items for Enables exploration	**Comments** (e.g., appropriateness of the items in relation to facet, conformity to the rules for scale item development on p. 7, suggestions alternative wording of items, propose new items)
1	"[The digital environment] is easy to explore"	
2	"I am free to explore in [The digital environment]"	
3	"[The digital environment] offers easy access to content"	
4	"[The digital environment] supports browsing of its content"	
5	"I can explore [The digital environment] using a variety of its features"	
6	"I can navigate freely within [The digital environment]"	
7	"[The digital environment] offers multiple pathways to information"	
8	"I can interact with information in [The digital environment]	
9	"There are lots of ways to access information in [The digital environment]"	
10		
11		
12		
13		

COMMENTS:

3.2 Trigger-rich

Definition: The digital environment is filled with a variety of information, ideas, or resources interesting and useful to the user.

	Proposed scalar items for Trigger-rich	**Comments** (e.g., appropriateness of the items in relation to facet, conformity to the rules for scale item development on p. 7, suggestions alternative wording of items, propose new items)
1	"The content contained in [The digital environment] is diverse"	
2	"[The digital environment] is rich with ideas"	
3	"[The digital environment] offers exposure to a wide variety of information"	
4	"[The digital environment] is information-intensive"	
5	"There is a depth of resources in [The digital environment"	
6	"[The digital environment] is rich with useful information"	
7	"[The digital environment] contains valuable information"	
8	"I would describe [The digital environment] as a treasure trove of information"	
9	"The content I come across in [The digital environment] is often timely	
10		
11		
12		
13		

COMMENTS:

3.3 Enables connections

Definition: The digital environment exposes users to combinations of information, ideas, or resources that make relationships between topics apparent.

	Proposed scalar items for Enables connections	**Comments** (e.g., appropriateness of the items in relation to facet, conformity to the rules for scale item development on p. 7, suggestions alternative wording of items, propose new items)
1	"[The digital environment] enables me to make connections between ideas"	
2	"[The digital environment] makes associations between topics apparent"	
3	"[The digital environment] presents juxtapositions of topics"	
4	"I can see connections between topics in [The digital environment]"	
5	"Making links between information is easy in [The digital environment]"	
6	"It is easy to see links between topics in [The digital environment]	
7	"In [The digital environment] I see relationships between topics I had not thought of before."	
8		
9		
10		
11		
12		

COMMENTS:

3.4 Highlights triggers

Definition: The digital environment actively points to or alerts users to interesting and useful information, ideas, or resources using visual, auditory, or tactile cues.

	Proposed scalar items for Highlights triggers	**Comments** (e.g., appropriateness of the items in relation to facet, conformity to the rules for scale item development on p. 7, suggestions alternative wording of items, propose new items)
1	"[The digital environment] often points to valuable information"	
2	"[The digital environment] draws my attention to useful information"	

	Proposed scalar items for Highlights triggers	**Comments** (e.g., appropriateness of the items in relation to facet, conformity to the rules for scale item development on p. 7, suggestions alternative wording of items, propose new items)
3	"[The digital environment] highlights information that interests me"	
4	"The way that [The digital environment] presents content often draws my attention"	
5	"[The digital environment] alerts me to information that helps me"	
6	"[The digital environment] points to information I can use"	
7	"Features of [The digital environment] catch my eye"	
8	"[The digital environment] entices me to take a closer look at resources."	
9	"In [The digital environment] I am exposed to information that I would not normally pay attention to"	
10	"[The digital environment] often has the content I need just when I need it"	
11		
12		
13		
14		

COMMENTS:

3.5 Leads to the unexpected

Definition: The digital environment provides fertile ground for unanticipated or surprising interactions with information, ideas, or resources.

	Proposed scalar items for Unexpected	**Comments** (e.g., appropriateness of the items in relation to facet, conformity to the rules for scale item development on p. 7, suggestions alternative wording of items, propose new items)
1	"I come across unexpected content in [The digital environment]"	
2	"I stumble upon the unexpected in [The digital environment]	
3	"I am often surprised by what I find in [The digital environment]"	

	Proposed scalar items for Unexpected	**Comments** (e.g., appropriateness of the items in relation to facet, conformity to the rules for scale item development on p. 7, suggestions alternative wording of items, propose new items)
4	"In [The digital environment] I come across topics by chance"	
5	"[The digital environment] often leads me to information I am not familiar with"	
6	"My interactions within [The digital environment] are often unexpectedly valuable"	
7	"I stumble upon information in [The digital environment]"	
8	"I can't anticipate what will come of my interactions in [The digital environment]"	
9		
10		
11		
12		
13		

COMMENTS:

4. General Comments

5. Your Contribution

May I acknowledge your contribution to my thesis? (yes/no)

Thank-you for your review. Please email this document to Lori McCay-Peet [mccay@dal.ca].

APPENDIX 4 STUDY 3

Appendix 4.1 Recruitment Instrument

Subject line: Invitation to participate in a study on *Defining Your Digital Environment*

Are you a university student over the age of 18? Please take 10-12 minutes of your time to respond to our survey which asks you to rate the appropriateness of definitions in relation to brief statements. Definitions and statements are related to individuals' experiences with websites, information systems and applications. At the end of the study you will have the chance to enter your name in a draw for one of four $50 gift certificates for Chapters Indigo. Chances of winning are approximately 1 in 25.

[Link to survey]

The study will start October 18th and will end when the target number of approximately 100 participants is reached. This survey is part of Lori McCay-Peet's Ph.D. research at Dalhousie University that is investigating individuals' experiences in digital environments. This research will help develop designs for better information systems.

Your participation in this study is voluntary and will be kept confidential. You may withdraw at any time.

If you have any questions, please contact Lori McCay-Peet at Dalhousie University: mccay@dal.ca

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Appendix 4.2 Consent Form and Study Instrument

Consent Form [page 1]
Defining Your Digital Environment

Principal investigator:
Lori McCay-Peet, PhD Candidate
Faculty of Management, Dalhousie University

Co-investigators:
Dr. Elaine G. Toms, University of Sheffield
Dr. Bertrum MacDonald, Dalhousie University

We are examining how people categorize statements in relation to descriptions of digital environments such as websites, information systems, and applications. Your participation will help us in the development of better digital environments.

You may participate if you are a university student 18 years or older. Participation is voluntary and anonymous and you may withdraw from participation at any time. Approximately 100 participants are being recruited for this research study.

We invite you to respond to this 15-20 minute survey in which you will be asked to complete a brief demographics questionnaire and rate a series of statements on the extent to which they match descriptions of technology.

You will have an opportunity to enter your email address (optional) at the end of this study for a chance to win 1 of 4 $50 (CAD) gift certificates for Chapters Indigo.

Once the study has been completed, all data will be retained in a locked cabinet in the research office for five years as per Dalhousie University's policy, after which it will be deleted or destroyed.

It is anticipated that no risk greater than that encountered in everyday life will be experienced. Participating in this research will not provide any personal benefits for you, but you may benefit from contemplating how digital environments support your information needs.

If you have any questions or require any additional information, please email Lori McCay-Peet [mccay@dal.ca] and close your browser window.

In the event that you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director of Dalhousie University's Office of Human Research Ethics Administration: (902) 494-1462.

To agree to participate in this research project, click "Next" below.

[Demographics – highest level of education, page 2]
What is the highest level of education that you have completed?

__ High school
__ College diploma
__ Undergraduate degree
__ Master's degree
__ Doctorate degree (e.g., PhD)
__ Professional degree (e.g., medicine, law)
__ Other (please describe in the comment section)
__ None
__ Prefer not to say

[Demographics – current education, page 3]
Which diplomas/degrees are you currently enrolled in?
__ High school
__ College diploma
__ Undergraduate degree
__ Master's degree
__ Doctorate degree (e.g., PhD)
__ Professional degree (e.g., medicine, law)
__ Other (please describe in the comment section)
__ None
__ Prefer not to say

[Demographics – gender, page 4]
What is your gender?
__ Male
__ Female
__ Prefer not to say

[Demographics – age, page 5]
What is your age group?
__ 18-20
__ 21-25
__ 26-30
__ 31-35
__ 36-40
__ 41-45
__ 46-50
__ 51-55
__ 56-60
__ 61-65
__ 65+
__ Prefer not to say

[Facet Example, page 6]
In this study you will be asked to rate how well a series of statements capture the meaning or gist of descriptive statements relating to technology such as websites, information systems, and applications.You will notice some repetition of the statements throughout.

This page and the next will take you through an example. Please read carefully to ensure you understand what you will be asked to do in the remainder of this study.

EXAMPLE:
How well do the three statements below capture the meaning or gist of this statement:
"it provides me with the information that I need"
NOTE: when "it" is used this refers to technologies such as websites, information systems, or applications. But rather than thinking about any specific technology or your

own experience with technology, please focus on whether the statements capture the meaning of the statement: "it provides me with the information that I need".

Please choose the appropriate response for each item:

	1 Not at all	2	3	4	5 Completely
1. I often find information in it that satisfies my needs	○	○	○	○	○
2. It sparks my imagination	○	○	○	○	○
3. I come across interesting information in it	○	○	○	○	○

EXAMPLE, continued**: [page 7]**

Let's take a look at the question again.

How well do the three statements below capture the meaning or gist of this statement:

"it provides me with the information that I need"

1. I often find information in it that satisfies my needs
This could be rated "5 (Completely)" because it fully captures the meaning of "it provides me with the information that I need"
2. It sparks my imagination
This could be rated "1 (Not at all)" because it does not appear to have anything to do with information needs
3. I come across interesting information in it
This could be rated a "2" or "3" because, while it doesn't capture the full meaning of "it provides me with the information that I need," it is not completely unrelated

	1 Not at all	2	3	4	5 Completely
1. I often find information in it that satisfies my needs	○	○	○	○	●
2. It sparks my imagination	●	○	○	○	○
3. I come across interesting information in it	○	●	○	○	○

[Facets intro, page 8]

Now you are ready to begin.
You will be asked to rate how well a series of statements capture the gist or meaning of five descriptive statements relating to technologies such as websites, information systems, and applications.

[Facet 1 intro, page 9]
On the next two pages you will be asked to rate how well a series of statements captures the gist or meaning of this statement:
"it supports exploration and examination of its information, ideas, or resources"

[Facet 1, pages 10-11, randomized]
How well do the following statements capture the *gist* or *meaning* of…
"it supports exploration and examination of its information, ideas, or resources"
Please choose the appropriate response for each item: [1 (not at all) to 5 (completely)]

1	2	3	4	5
Not at all				Completely
○	○	○	○	○

[See section 5.3.4.1 Study Design for order of items in the four surveys]

Group 1 (Surveys 1 and 2)	Group 2 (Surveys 3 and 4)
E6 There are many ways to discover information in it	U3 I am often surprised by what I find in it
H6 Features of it catch my eye	C3 I can see connections between topics in it
T6 I often find information of value to me in it	U2 I encounter the unexpected in it
U7 I stumble upon information in it	H2 It draws my attention to useful information
T7 I would describe it as a treasure trove of information	C1 It enables me to make connections between ideas
U4 In it I come across topics by chance	H3 It highlights information that interests me
C5 In it I see relationships between topics I had not thought of before	E2 It supports exploration
H5 It alerts me to information that helps me	E1 It is easy to explore
C7 It allows me to make insightful connections	T2 It is rich with interesting ideas

NOTE: when "it" is used this refers to technologies such as websites, information systems, or applications. But rather than thinking about any specific technology or your own experience with technology, please focus on whether the statements capture the meaning of the statement: "it supports exploration and examination of its information, ideas, or resources".

How well do the following statements capture the *gist* or *meaning* of…
"it supports exploration and examination of its information, ideas, or resources"
Please choose the appropriate response for each item: [1 (not at all) to 5 (completely)]

1	2	3	4	5
Not at all				Completely
○	○	○	○	○

[See section 5.3.4.1 Study Design for order of items in the four surveys]

Group 1 (Surveys 1 and 2)	Group 2 (Surveys 3 and 4)
U5 It exposes me to information I am not familiar with H7 It exposes me to information that I would not normally pay attention to C6 It helps me to make useful connections between resources E7 It invites examination of its content C4 It is easy to see links between information in it E4 It offers multiple pathways to information T5 It is full of information useful to me U6 It leads me to information that is unexpectedly valuable E5 There are lots of ways to access information in it	C2 It makes associations between ideas obvious T3 It offers exposure to a wide variety of information H1 It often points to valuable information T1 The content contained in it is diverse H4 The way that it presents content often captures my attention T4 There is a depth of information in it U1 I bump into unexpected content in it E3 It is easy to wander around in it

NOTE: when "it" is used this refers to technologies such as websites, information systems, or applications. But rather than thinking about any specific technology or your own experience with technology, please focus on whether the statements capture the meaning of the statement: "it supports exploration and examination of its information, ideas, or resources".

[The remaining 4 facets are presented in the same manner as Facet 1 above -- the only change is the facet definition]
[Facet 2 intro, Facet 2; pages 12-14]
"it contains a variety of information, ideas, or resources that are interesting and useful to the user"

[Facet 3 intro, Facet 3; pages 15-17]
"it makes relationships or connections between information, ideas, or resources apparent"

[Facet 4 intro, Facet 4; pages 18-20]
"it brings interesting and useful information, ideas, or resources to the user's attention"

[Facet 5 intro, Facet 5; pages 21-23]

"it provides opportunities for unexpected interactions with information, ideas, or resources"

[Draw; page 24]
Almost done!
If you would like to be entered in a draw for one of four $50 (CAD) gift certificates for Chapters Indigo please enter your email address in the space below.

[Consent form copy; page 25]
Would you like to have this study's consent form emailed to you? If so, please enter your email address in the space below.

[Comments; page 26]
Comments?

[Thank-you; page 27]
Thank-you for your participation!
Note: If you are one of the winners of the four gift certificates you will be notified the week of November 12th. The subject line of the email will read "Defining the digital environment study -- winner".

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APPENDIX 5 STUDY 4

Appendix 5.1 Recruitment Instrument

Subject line: Invitation to participate in a study on *Your Experience in Digital Environments*

Are you a professional or graduate student who frequently searches for and monitors information relating to your work or area of research? We are interested in your perceptions of the digital environments (e.g., websites, intranets) that you use and how these perceptions may be related to your personality traits and work environment.

Please take 15-20 minutes of your time to respond to our survey. You will have the chance to enter your name in a draw for one of twenty $20 gift certificates for Amazon.ca.

[Link to study]

The study will start February 13, 2013 and will continue until the target number of 300-400 participants is met and may be completed at your convenience. This survey is part of Lori McCay-Peet's Ph.D. research at Dalhousie University that is investigating individuals' experiences in digital environments. This research will help in the development of better digital environments.

Your participation in this study is voluntary and will be kept confidential. You may withdraw at any time.

If you have any questions, please contact Lori McCay-Peet at Dalhousie University: mccay@dal.ca

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Appendix 5.2 Differences by Survey Group

To explore differences by Survey Group, a MANOVA was conducted on eleven dependent variables, including the four underlying factors of the SDE scale (SDE-Trigger-Rich, Enables Connections, Highlights Triggers, and Leads to the Unexpected), the underlying factors of the Serendipity (Serendipity-Specific DE, DEs, General) and Extraversion, Openness to Experience, Creative Environment Perceptions, and Locus of Control of Behaviour. The independent variable was Survey Group. Using Wilk's criterion the composite dependent variate was significantly affected by Survey Group, Wilk's $\lambda = F[11, 277) = 5.55$, $p < .001$, partial $\eta^2 = .18$ (see Table 34). Univariate ANOVAs were conducted on each dependent measure separately to determine the cause for the significant multivariate effect. Survey Group significantly affected two of the four underlying factors of the SDE scale:

- SDE-Trigger-Rich, $F[1, 287] = 5.90$, $p < .05$, partial $\eta^2 = .02$; and
- SDE-Leads to the Unexpected, $F[1, 287] = 32.79$, $p < .001$, partial $\eta^2 = .10$.

Furthermore, Survey Group had a significant effect on the Serendipity-Specific DE, $F[1, 287] = 17.71$, $p < .001$, partial $\eta^2 = .06$. Means and standard deviations of the eleven dependent variables for the two groups are presented in Table 35.

Those in Survey 2 who were asked to select a digital environment in which they find information they had not planned to find reported experiencing serendipity *more frequently* in their selected digital environment (S-SPE) (M = 3.41, SD = .67) than those in Survey 1 (M = 3.03, SD = .85) who were asked to select a digital environment they use to find specific information. Those in Survey 1 perceived the DEs they selected as more Trigger-Rich (TRIGG) (M = 4.39, SD = .58) than those in Survey 2 (M = 4.22, SD = .63). And finally, those in Survey 2 perceived their the DEs they selected were more likely to Lead to the Unexpected (UNEX) (M = 4.22, SD = .65) than those in Survey 1 (M = 3.71, SD = .81). No statistically significant effects were observed for the remaining study variables.

Table 34 Multivariate and univariate analysis of variance for study variables as a function of Survey Group

	Multivariate		*Univariate*			
Source	*Df*	*F*[a]	*TRIGG*	*CONN*	*HIGH*	*UNEX*
F Ratios for Survey Group	11	5.55	5.90*	1.66	3.68	32.79***
MSE			2.16	1.31	2.47	18.09

	Multivariate		*Univariate*		
	Df	*F*[a]	*S-Spe*	*S-DEs*	*S-Gen*
Source					
F Ratios for Survey Group	11	5.55	17.71***	.26	.16
MSE			10.40	.15	.08

	Multivariate		*Univariate*			
Source	*Df*	*F*[a]	*EXTRA*	*OPEN*	*CEP*	*LCB*
F Ratios for Survey Group	11	5.55	.10	.00	.00	.23
MSE			.04	.00	.00	.07

Note. $N = 289$. *$p < .05$; **$p < .01$; ***$p < .001$ (2-tailed)
Multivariate *F* ratios were generated from Wilk's criterion.
a. Multivariate $df = 11, 277$.
b. Univariate $df = 1, 287$.

Table 35 Mean scores and standard deviations for study variables as a function of Survey Group

Survey	*TRIGG*		*CONN*		*HIGH*		*UNEX*	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Survey 1	4.40	.59	3.51	.95	3.56	.89	3.71	.81
Survey 2	4.22	.63	3.64	.82	3.75	.73	4.22	.65

Survey	*S-Spe*		*S-DEs*		*S-Gen*	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Survey 1	3.03	.85	3.66	.78	3.42	.69
Survey 2	3.41	.67	3.71	.73	3.39	.68

Survey	*EXTRA*		*OPEN*		*CEP*		*LCB*	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Survey 1	3.48	.60	3.88	.45	3.63	.63	1.61	.55
Survey 2	3.46	.58	3.88	.53	3.63	.69	1.58	.55

Note. $N = 289$.
TRIGG=SDE-Trigger-Rich; CONN=SDE-Enables Connections; HIGH=SDE-Highlights Triggers; UNEX=SDE-Leads to the Unexpected; S-Spe=Serendipity-Specific DE; S-DEs=Serendipity-DEs; S-Gen=Serendipity-General; EXTRA=Extraversion; OPEN=Openness to Experience; CEP=Creative Environment Perceptions; LCB=Locus of Control of Behaviour

Appendix 5.3 Consent Form and Study Instrument

Consent Form [page 1]
Digital Environments

Principal Investigator:
Lori McCay-Peet, PhD Candidate
Faculty of Management, Dalhousie University

Co-investigators:
Dr. Elaine G. Toms, Information School, University of Sheffield
Dr. Bertrum MacDonald, School of Information Management, Dalhousie University

We are interested in your perceptions of the digital environments (e.g., websites, intranets) that you use and how these perceptions may be related to your personality traits and work environment. Your participation will help us in the development of better digital environments.

You may participate if you are 18 years or older and are either a:

1) A professional or academic who frequently searches for and monitors information relating to your work

2) A graduate student conducting thesis work

Approximately 300-400 participants are being recruited for this research study. Participation is voluntary and anonymous and you may withdraw from participation at any time. You may be quoted in publications and presentations emanating from this research, but you will only be referred to by your assigned participant ID number.

We invite you to respond to this 15-20 minute survey in which you will be asked to respond to questions relating to your experience in digital environments, your work environment, personality traits, as well as a brief demographics questionnaire.

You will have an opportunity to enter your email address (optional) at the end of this study for a chance to win 1 of 20 $20 (CAD) gift certificates for Amazon.ca.

Once the study has been completed, all data will be retained in a locked cabinet in the research office for five years as per Dalhousie University's policy, after which it will be deleted or destroyed.

It is anticipated that no risk greater than that encountered in everyday life will be experienced. Participating in this research will not provide any personal benefits for you, but you may gain insights into your own information search behaviours.

If you have any questions or require any additional information, please email Lori McCay-Peet [istudy@dal.ca] and close your browser window.

In the event that you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director of Dalhousie University's Office of Human Research Ethics Administration: (902) 494-1462.

To agree to participate in this research project, click "Next" below.

[Demographics intro, page 2]
You will first be asked to respond to a brief demographics questionnaire.

[Demographics – highest level of education, page 3]
What is the highest level of education that you have *completed*?

__ High school/Secondary school
__ College/Further education college
__ Undergraduate
__ Master's
__ Doctorate (e.g., PhD)
__ Professional degree (e.g., medicine, law)
__ Other [please describe]

[Demographics – current education, page 4]
Which diplomas/degrees are you *currently* enrolled in?
__ None
__ High school/secondary school
__ College/Further education college
__ Undergraduate
__ Master's
__ Doctorate (e.g., PhD)
__ Professional degree (e.g., medicine, law)
__ Other [please describe]

[Demographics – gender, page 5]
What is your gender?
__ Male
__ Female
__ Other

[Demographics – age, page 6]
What is your age group?
__ 18-20
__ 21-25
__ 26-30
__ 31-35
__ 36-40
__ 41-45
__ 46-50
__ 51-55
__ 56-60
__ 61-65
__ 65+
__ Prefer not to say

[Demographics – age, page 7]
What best describes your current situation?
__ I am a student
__ I am employed
__ Other

If you are both a student and employed, select "I am a student" if you are a student more than 50% of your time.

[Demographics – if participant is employed, page 8]
What best describes your current occupation?
__ Management
__ Business, Finance and Administration
__ Natural and Applied Sciences
__ Health
__ Social Science, Education, Government Service and Religion
__ Art, Culture, Recreation and Sport
__ Sales and Service
__ Trades, Transport and Equipment Operators
__ Primary Industry
__ Processing, Manufacturing and Utilities
__ Other [please describe]

[Demographics – if participant is a student, page 9]
What best describes your area of study?
__ Humanities (e.g., history, literature, visual arts)
__ Social sciences (e.g., anthropology, economics, psychology)
__ Natural sciences (e.g., earth sciences, life sciences, chemistry)
__ Formal sciences (e.g., computer sciences, mathematics, statistics)
__ Professions and Applied sciences (e.g., business, education, health science)
__ Other [please describe]

[Digital environment – intro, page 10]
Next, you will be asked several questions about your experience in a digital environment of your choice. Here are just a few examples of different types of digital environments:
__ your organization's intranet
__ a government website
__ ACM digital library
__ Twitter social media site
__ CNN website
__ Digg social news website

[Digital environment – selection, page 11]
What digital environment (e.g., intranet, website) comes to mind when you read the following statement?

> [Survey Group 1 given this statement] I use this digital environment to find specific information or resources that are useful to my work or academic studies.
>
> [Survey Group 2 given this statement] When I use this digital environment, I find information, ideas, or resources that are useful to my work or academic studies that I had not planned to find.

Please indicate the name of one digital environment that comes to mind in the space provided below.

Examples: your organization's intranet, a government website, ACM digital library, Twitter social media site, CNN website, Digg social news website

[Digital environment – use, page 12]
How often do you use the digital environment you selected?
- o daily
- o weekly
- o monthly
- o less than monthly

[Digital environment – access, page 13]
How do you usually access the digital environment you selected?
- o desktop
- o laptop
- o tablet
- o smartphone
- o other device: [please describe]

[Serendipitous digital environment scale, page 14]
Thinking of your experience in the digital environment you selected, please indicate your level of agreement with each of the following statements. If there is a statement that is unclear to you, please select "I Don't Know".

NOTE: You may find these statements repetitive. This is intentional and will help us develop a better set of questions.

1	2	3	4	5	
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	I Don't Know
○	○	○	○	○	○

[E1] t is easy to explore its content.
[E2] It supports exploration.
[E3] It is easy to wander around in it.
[E6] There are many ways to explore information in it.
[E7] It invites examination of its content.
[E8] It is an instrument for discovery.
[E9] It is a tool for exploration.
[T1] The content contained in it is diverse.
[T2] It is rich with interesting ideas.
[T3] It offers a wide variety of information.
[T4] There is a depth of information in it.
[T5] It is full of information that is useful to me.
[T6] I find information that is of value to me in it.
[T7] It is a treasure trove of information.

[C1] It enables me to make connections between ideas.
[C2] Associations between ideas become obvious in it.
[C3] I can see connections between topics in it.
[C4] It is easy to see links between information in it.
[C6] I make useful connections in it.
[C8] The features of it help me see connections between its content.
[C9] I come to understand relationships between ideas in it.
[H1] I am directed toward valuable information in it.
[H2] It has features that ensure that my attention is drawn to useful information.
[H3] Information that interests me is highlighted in it.
[H4] The way that it presents content captures my attention.
[H5] I am alerted to information in it that helps me.
[H7] I notice content I wouldn't normally pay attention to in it.
[H8] It has features that draw my attention to information.
[H9] I am pointed toward content in it.
[H10] It has features that alert me to information.
[U1] I bump into unexpected content in it.
[U2] I encounter the unexpected in it.
[U3] I am surprised by what I find in it.
[U4] I come across content by chance in it.
[U5] I am exposed to unanticipated content in it.
[U6] My interactions in it are unexpectedly valuable.
[U7] I stumble upon information in it.

[Serendipity – specific digital environment, page 15]
Thinking of your experience in the digital environment you selected, please indicate how frequently you experience the following.

Never	Rarely	Sometimes	Frequently	Very frequently	I Don't Know
○	○	○	○	○	○

[S-SpecificDE-1] In the digital environment I selected, I experience serendipity that has an impact on my everyday life.
[S-SpecificDE-2] In the digital environment I selected, I experience serendipity that has an impact on my work.
[S-SpecificDE-3] I encounter useful information, ideas, or resources that I am not looking for when I use the digital environment I selected.
[S-SpecificDE-4] In the digital environment I selected, I experience mixes of unexpectedness and insight that lead to valuable, unanticipated outcomes.

[Serendipity – digital environments in general intro, page 16]
Now, think about your experience in digital environments in general, not just the one you selected.

[Serendipity – digital environments in general, page 17]
Please indicate how frequently you experience the following.

Never	Rarely	Sometimes	Frequently	Very frequently	I Don't Know
○	○	○	○	○	○

[S-DEs-1] In digital environments I experience serendipity that has an impact on my everyday life.
[S-DEs-2] In digital environments I experience serendipity that has an impact on my work.
[S-DEs-3] I encounter useful information, ideas, or resources that I am not looking for when I use digital environments.
[S-DEs-4] In digital environments I experience mixes of unexpectedness and insight that lead to valuable, unanticipated outcomes.

[Time spent searching Internet, page 18]
How much time do you spend on an average day actively searching for information on the Internet?
__ Less than 1 hour
__ 1-2 hours
__ 2-3 hours
__ 3-4 hours
__ More than 4 hours

[Serendipity – in general intro, page 19]
Now, think about your life experiences in general, not just in digital environments.

[Serendipity – in general, page 20]
Please indicate how frequently you experience the following.

Never	Rarely	Sometimes	Frequently	Very frequently	I Don't Know
○	○	○	○	○	○

[S-Gen-1] I experience serendipity that has an impact on my everyday life.
[S-Gen-2] I experience serendipity that has an impact on my work.
[S-Gen-3] I encounter useful information, ideas, or resources that I am not looking for.
[S-Gen-4] I experience mixes of unexpectedness and insight that lead to valuable, unanticipated outcomes.

Think about your life experiences in general, not just in digital environments.

[Intro to rest of survey, page 21]
You will now be asked to complete a series of questionnaires that relate to you and your work environment.

[pages 22-25 randomly assigned creative environment, extraversion, openness to experience, and locus of the control of behaviour questionnaires below]

[The creative environment perceptions questionnaire (Mayfield & Mayfield, 2010)]
Please indicate your level of agreement with the following considering what best describes your current work place or academic environment. [Wording adapted from Mayfield and Mayfield's original directions: "Please place an X in the brackets by the answer that best describes your current work place"; same scale format and items used]

Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not Applicable
○	○	○	○	○	○

1. My supervisor encourages me to be creative.
2. My work group is supportive of new ways of doing things.
3. My organization encourages me to work creatively.
4. I have the resources I need to do my job.
5. My work is challenging.
6. I have control over how I do my work.
7. My organization's politics makes it difficult to be creative.
8. My organization's policies impede spontaneity in the workplace.
9. It is difficult to be creative with the work deadlines I have.

[Extraversion questionnaire (Lee & Ashton, 2004)]
On the following pages you will find a series of statements about you. Please read each statement and decide how much you agree or disagree with that statement. [These are Lee & Ashton's original directions]

1	2	3	4	5
Strongly disagree	Disagree	neutral (neither agree nor disagree)	Agree	Strongly agree

1) I feel reasonably satisfied with myself overall.
2) I think that most people like some aspects of my personality.
3) I feel that I am an unpopular person.
4) I sometimes feel that I am a worthless person.
5) I rarely express my opinions in group meetings.
6) In social situations, I'm usually the one who makes the first move.
7) When I'm in a group of people, I'm often the one who speaks on behalf of the group.
8) I tend to feel quite self-conscious when speaking in front of a group of people.
9) I avoid making "small talk" with people.
10) I enjoy having lots of people around to talk with.
11) I prefer jobs that involve active social interaction to those that involve working alone.
12) The first thing that I always do in a new place is to make friends.
13) I am energetic nearly all the time.
14) On most days, I feel cheerful and optimistic.
15) People often tell me that I should try to cheer up.

16) Most people are more upbeat and dynamic than I generally am.

[Openness to experience scale (Lee & Ashton, 2004)]
On the following pages you will find a series of statements about you. Please read each statement and decide how much you agree or disagree with that statement. [These are Lee & Ashton's original directions]

1	2	3	4	5
Strongly disagree	Disagree	neutral (neither agree nor disagree)	Agree	Strongly agree

1) I would be quite bored by a visit to an art gallery.
2) I wouldn't spend my time reading a book of poetry.
3) If I had the opportunity, I would like to attend a classical music concert.
4) Sometimes I like to just watch the wind as it blows through the trees.
5) I'm interested in learning about the history and politics of other countries.
6) I enjoy looking at maps of different places.
7) I would be very bored by a book about the history of science and technology.
8) I've never really enjoyed looking through an encyclopedia.
9) I would like a job that requires following a routine rather than being creative.
10) I would enjoy creating a work of art, such as a novel, a song, or a painting.
11) People have often told me that I have a good imagination.
12) I don't think of myself as the artistic or creative type.
13) I think that paying attention to radical ideas is a waste of time.
14) I like people who have unconventional views.
15) I think of myself as a somewhat eccentric person.
16) I find it boring to discuss philosophy.

[Locus of control of behaviour questionnaire (Craig et al., 1984)]
Directions: Below are a number of statements about how various topics affect your personal beliefs. There are no right or wrong answers. For every item there are a large number of people who agree or disagree. Could you please put in the appropriate space the choice you believe to be true? Answer all the questions. [These are Craig et al.'s original directions]

0	1	2	3	4	5
Strongly disagree	Generally disagree	Somewhat Disagree	Somewhat agree	Generally agree	Strongly agree

1) I can anticipate difficulties and take action to avoid them
2) A great deal of what happens to me is probably just a matter of chance
3) Everyone knows that luck or chance determine one's future
4) I can control my problem(s) only if I have outside support
5) When I make plans, I am almost certain that I can make them work
6) My problem(s) will dominate me all my life

7) My mistakes and problems are my responsibility to deal with
8) Becoming a success is a matter of hard work, luck has little or nothingto do with it
9) My life is controlled by outside actions and events
10) People are victims of circumstance beyond their control
11) To continually manage my problems I need professional help
12) When I am under stress, the tightness in my muscles is due to things outside my control
13) I believe a person can really be a master of his fate
14) It is impossible to control my irregular and fast breathing when I am having difficulties
15) I understand why my problem(s) varies so much form one occasion to the next
16) I am confident of being able to deal successfully with future problems.
17) In my case maintaining control over my problem(s) is due mostly to luck

[Final questions, page 26]
Almost done!

Would you like to be entered in a draw for one of twenty $20 (CAD) gift certificates for Amazon.ca [Yes/No, thanks]

Would you be interested in receiving recruitment notices for future web-based studies relating to the one you just completed? [Yes/No, thanks]

Would you like to have this study's consent form emailed to you? [Yes/No, thanks]

[Email, page 27]
If you answered "Yes" to any of the preceding questions, please enter your email in the space provided. Your email address will be stored separately from your responses to this survey.
[space to enter email]

[Comments, page 28]
Comments on the survey? [not a required field]

[Thank-you, page 29]

Thank-you for your participation!

We need more participants! Please feel free to send out a link to this survey to your colleagues [SURVEY LINK].

Note: If you are one of the winners of the 20 gift certificates you will be notified by email. The subject line of the email will read "Digital environments study -- winner".

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