Exploring Internet Research Process and Construction Tasks as a Technological Skill Development Tool

by

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An oral defense of this thesis took place on Monday, May 2, in front of the following examining committee:

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The above committee determined that the thesis is acceptable in form and content and that a satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate during an oral examination. A signed copy of the Certificate of Approval is available from the School of Graduate and Postdoctoral Studies.

ABSTRACT

Continuous digital skill development is important in today's workforce due to ever evolving technologies and workforce expectations. This study aims to help develop technological skills through a combination of research process frameworks and a constructionist creation tasks. This framework is designed to remove barriers often seen as inhibiting computer usage. This two-phase study utilizes a mixed-methods methodology through the use of a pre-task survey, live construction task, and a post-task questionnaire. Participants were asked to create a brochure in Microsoft Word for a tourist attraction with the assistance of the Internet. After the brochure was complete, participants were given an opportunity to reflect on the learning experience. Participants that spent more time creating were found to be more likely to report technological skill development. Changes to the task design were recommended for future studies.

Keywords:

technological skill development; digital skills; digital competencies; constructionism; internet searching; research process; exploratory searching; task design; mixed-methods

AUTHOR'S DECLARATION

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STATEMENT OF CONTRIBUTIONS

I hereby certify that I am the sole author of this thesis and that no part of this thesis has been published or submitted for publication. I have used standard referencing practices to acknowledge ideas, research techniques, or other materials that belong to others. Furthermore, I hereby certify that I am the sole source of the creative works and/or inventive knowledge described in this thesis.

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LIST OF ABBREVIATIONS AND SYMBOLS

CSE	Computer Self-Efficacy
DCP	Digital Competency Profiler
GREx	Global Readiness Explorer
GTCU	General Technology Competency and Use
ICT	Information and Communications Technology
IPS	Information Problem Solving
IR	Information Retrieval
ISP	Information Search Process
REB	Research Ethics Board

Introduction

Students across a variety of education levels need to develop life-long learning skills due to the uncertainty of future employment markets and the relevancy of taught skills to future, unknown job requirements (Kirschner & Stoyanov, 2020). The global workforce is increasingly prioritizing knowledge creation and lifelong skills development while at same time digital skills among knowledge workers can vary considerably (van Laar et al., 2019). This may be exacerbated by the mass migration to work from home policies instituted by companies due to the COVID-19 pandemic, which will likely not return to its pre-pandemic form (Mehta, 2021). This may mean that people entering the workforce should be able to adapt to new technology demands and have the ability to develop digital skills when the need arises.

In addition, learners can be affected by barriers to information seeking that include inabilities to articulate their needs and low self-efficacy in information seeking (Savoleinen, 2015). Higher education students with little computer experience may have high computer anxiety and low computer self-efficacy (Schlebusch, 2018), which can create barriers to technological skill development. This may make it difficult for learners to adapt to technologically rich learning environments or workspaces. Even among users who self-report strong search skills and strong technical knowledge, solving problems within technological devices can still be difficult (Rutter et al., 2019).

In this thesis, I will be seeking to develop technological skills using constructionist (Papert, 1993) learning tasks and research frameworks in both offline (Kuhlthau, 2004) and online contexts (Brand-Gruwel et al., 2009; Marchionini, 2006). Technological skills in this context refer to skills required to interact with software on a general level (clicking, navigating menus) and on a software specific level (understanding software functionality). Such skills are commonly studied and grouped in skill categories, also referred to as competencies, that describe a user's ability to both interact with technological devices (technical competency) and the information found through such devices (informational competency) (Desjardins, 2005; van Deursen & van Dijk, 2010).

This study aims to use research process frameworks as a tool to help learners engage with information problems in digital spaces. Papert's (1993) constructionism learning theory has been incorporated into the study because it also promotes engagement with learning problems through the act of creating learning objects. The learning object, in a constructionist sense, is an object created by that learner that can be used for expression and development of ideas and for reflection. By combining the research process and constructionism—thereby promoting engagement in the learning process—this study aims to help develop technological skills in a manner that is sustainable for future skill development.

Research Questions

This study aims to identify behavioural profiles in a construction-based online research task in an online environment that can be linked to self-reported claims of technological skill development. In other words, the purpose of this study is to examine factors that may help lead to technological skill development through engaging learners in an informational competency-based task.

Research on research process, task complexity, and constructionism were used to helped design the task, while research on digital skills and computer self-efficacy were used to help measure technological activities and identify barriers to computer usage.

Following that, a short construction-based online research task was developed for use with live participants in a recorded session, which was later analyzed. After the session, the participants were asked to self-report any technological skill development and assess their satisfaction with their created object and research process. Using this study method, the following research questions were developed and investigated.

1. R1 – What significant correlations exist between construction and research task activities and self-reported post-task questionnaire results?
2. R2 – What behavioural profiles can be established that may help increase technological skill development?
3. R3 – How can engagement in a construction-based online research task provide evidence for technical or informational skill development?
4. R4 – What barriers to construction-based online research tasks can be identified? Can any identified barriers be mitigated?

Literature Review

The framework for this study involves a synthesis of several different research fields: research process, task design, and digital skills. Research process is a field of study centered on information searching and presenting. In this study, the research process will be mostly described in terms of its relation to the Internet. Task design is centered on the categorization and fundamental attributes of a task. This study will discuss task design as it relates to leaner engagement in the learning process. Finally, the study of digitals skills is a field centered on the skills required to engage with and take advantage of modern computer technology. This study will discuss digital skills as they relate to Internet and software usage. These fields will be combined to form the framework for the usage of digital creation tasks that utilize the Internet.

Research Process

A distinction needs to be made between information retrieval (IR) and research process. The two concepts are inter-related, but they form separate frameworks. Literature on research processes predates the Internet, with bottom-up (i.e., keyword-based) and top-down (i.e., browsing-based) strategies as examples of search strategies utilized by web searchers (Sharit et al., 2015). The former exemplifies IR frameworks while the latter could be viewed as a starting point for research process frameworks.

Bates (1979) provided an early systemization of information searching tactics, which were identified and defined to help model overall information search strategy. Bates differentiated between tactics and strategies, where a tactic is the move to advance a search and a strategy is “a plan for the whole search” (1979, p. 207). Search strategies typically fall under IR frameworks that aim to describe how information is located.

Kuhlthau (2004), through a series of longitudinal studies during the 80s and 90s, provided a reconceptualization of research as a learning process with the Information Search Process (ISP) model. Kuhlthau found during these studies that the act of researching involved multiple iterations of information searching as a result of the researcher navigating the current gaps in their knowledge and the evaluation of information acquired while searching. The act of researching caused participants to change perspectives or narrow their focus, which in turn led to new avenues of research. In other words, Kuhlthau’s model expanded the act of research from information retrieval, in which information is the end-product of the research process, to a process whereby learning occurs during the act of research. Later frameworks of researching sometimes refer to this type of process as searching-as-learning or searching to learn (Rieh et al., 2016; Vakkari, 2016; Ghosh et al., 2018; Marchionini, 2006). However, this study will continue to use the term research process because while the terminology is not consistent, the general structure of the various research process frameworks is.

Research process frameworks mark an intersection between constructivist conceptions of learning and information searching processes. Where an IR framework may prioritize the finding of declarative knowledge as an end goal, a research process framework may prioritize interaction between the searcher and the information (Rieh et al., 2016). Research process frameworks may also not draw a large distinction between information seeking and learning processes (Ghosh et al., 2018), instead viewing these processes as co-existing and occurring simultaneously.

This study prioritizes three key research process frameworks that each provide important concepts to the conceptualization of the research process. Kuhlthau's (2004) previously mentioned ISP model provided a strong foundational lens to view the research process as more than an IR process, but as a constructivist learning process. Marchionini's (2006) Exploratory Search framework conceptualized the Internet as more than an IR system, but as a learning environment. Finally, Brand-Gruwel et al.'s (2009) Information Problem Solving (IPS) model built on Kuhlthau's ISP model and incorporates the Internet research behaviour into information organization and synthesis. The three frameworks overlap in that they all incorporate a constructivist, sense-making learning process into the framework. Learning is not defined for them as the acquisition of declarative knowledge like it might be in an IR framework, but instead in terms of action, creation, and knowledge generation. The searcher must also evaluate, organize, and synthesize the information into something that achieves the desired goal. Kulthau (2004) called it Presentation, Brand-Gruwel et al. (2009) called it Organize and Present, and Marchionini (2006) called it Synthesis. This is a key difference from IR models because it incorporates a form of synthesis or creation into the research model. Where an IR framework may view information retrieval as an endpoint, research process considers it to be part of a larger series of processes. More recent studies on information searching, information comprehension, and digital literacy still use similar frameworks to describe online reading and learning processes (Kiili et al., 2018; Cho et al., 2017).

Another difference between IR frameworks and broader research process frameworks is their criteria for defining success. Information searching studies tend to focus on correctness as an outcome to an information search (Aula et al., 2010; Hahnel et al., 2018; Sharit et al., 2015; Singer et al., 2012). In other words, the information search task will be a question for which there can be a correct or incorrect answer. A successful outcome for these types of problems would be one that contains a correct answer. However, in studies with frameworks that more closely resemble a research process framework, researchers may opt for more creative or complex exercises. For instance, a participant may be asked to research a topic, form an opinion, and then validate that opinion (Ulyshen et al., 2015; Ghosh et al., 2018), which should invoke higher order learning processes of analysis and evaluation (Anderson & Krathwohl, 2001).

Research on research processes tends to be situated within the library sciences with university students as the target population (O'Brien et al., 2017). Behavioural differences between novice and expert searchers are a common area of study. Some studies use educational level as a means for determining differing levels of search expertise. For populations or raters with an assumed high level of search expertise, studies have used faculty or doctoral students (Rieh, 2002; Brand-Gruwel et al., 2005; Hahnel et al., 2018) or librarians (Wood et al., 2016). Conversely, undergraduate students have been used as low search expertise population samples (Brand-Gruwel et al., 2005; Wood et al., 2016). However, there may be issues with relying on education level as a determinant of search expertise because their expertise is assumed and hasn't been tested. Self-reporting is another method of determining expertise without relying on assumptions from the researcher (Rutter et al., 2019). The variety of metrics to determine expertise can cause difficulty in comparing search strategies and outcomes across studies (Aula et al., 2010).

Domain knowledge is another area of information searching research that describes the effect of a searcher's knowledge of a field on their search behaviour within that field. Similar to search expertise, education level has also been used to represent the independent variable when studying the effects of domain knowledge on Internet searches (Brand-Gruwel et al., 2017; Wood et al., 2016). However, academic and everyday information searching behaviour have also been found to be connected to each other (Ding & Ma, 2013; Given, 2002), which suggests that library sciences could benefit from Internet research beyond academic contexts. In other words, information searching behaviour in one domain (everyday tasks) can influence behaviour in another domain (academic) and vice versa.

Research on research processes can also vary in scope. Some areas of research include querying (Walhout et al., 2017), source selection (Ibieta et al., 2019) or source evaluation (Brand-Gruwel et al., 2017) on smaller scale projects, while holistic information searching models (Brand-Gruwel et al., 2009) dominate the large-scale searches. However, examining information relevance, source evaluation, and fact-finding may not always be the best way to examine search behaviour. For example, when solving an everyday technical task, the relevance of the information or the credibility of the source may not be as important as the usefulness of the information in relation to the searchers problem (Rutter et al., 2019). The participants could determine information usefulness as it relates to their problem themselves instead of requiring the researcher to independently verify information reliability.

Research process research can attempt to replicate realistic searching behaviour by using tasks that reflect real world scenarios (Rutter et al., 2019). For example, Hendahewa & Shah (2015) prioritized flexibility and longer time limits as key areas that have been neglected from previous research. To them, flexibility meant allowing participants to use any search engines they liked, to select tasks that they prefer, and to work on their own computer. From the perspective of a researcher, this suggests that classical experiments may not be ideal for studying research process because the controlled nature of an experiment does not reflect the reality of research process behaviour. As such, it may be more important to create task studies that exhibit high levels of ecological validity (Andrade, 2018). Additionally, research process behaviour can change in real time based on the prior actions and search trails (i.e., the history of searches within a problem) of the searcher (Hendahewa & Shah, 2017), which adds a level of complexity when modeling it. While some studies might attempt to control for these factors, frameworks like those cited in this section will acknowledge that behaviours, attitudes, and direction of inquiry is likely to change during the research process. For these reasons, complex tasks, which are often ill-defined, abstract, or have uncertain goals and strategies, may be ideal for the study of research process because their uncertain nature may help increase involvement in the research problem.

Task Complexity

There is no universal agreement on the definition of task complexity, and research on the subject has been done in a wide variety of fields (Liu & Li, 2012). Campbell (1988), in his review of the literature, identified the volume of pathways or outcomes, whether outcomes conflict, and the uncertainty of information linkages as characteristics of task complexity. Wildemuth et al. (2014) built on this definition by adding indeterminability as an attribute of task complexity. In other words, a complex task is often open-ended in both process (i.e., multiple avenues of exploration and creation) and result (i.e., multiple valid solutions). A person performing a complex task will have to reconcile multiple pieces of information and make subjective decisions to achieve an outcome.

Task complexity can also be described through abstraction, in which task complexity increases can be linked to increased cognitive demands or knowledge generation (Mosenthal, 1998). For example, Watts (1991) differentiated between problem types by describing the cognitive demands required to the learner. Simple problems include both the goal and the means to achieve the goal. Complexity increases then becomes a matter of reduction, where the means of achieving the problem goal become less clear. At its most complex, the learner may need to determine on their own if there is even a problem to solve. Similar task complexity definitions can also be found in Savin-

Baden’s (2000) models of problem-based learning, which achieved abstraction by removing boundaries between disciplines to allow problems to become multidimensional.

All these views on task complexity share what Kuhlthau (2004) described as the “uncertainty principle.” The uncertainty principle describes a state in which the learner is experiencing a gap between their current situation and their goal. In this state, the learner can be expected to be confused, perhaps frustrated, with vague ideas about their learning task. In Kuhlthau’s view, this state of uncertainty is the impetus to begin the act of learning because it forces the researcher to address a gap in their understanding. van Oostveen et al. (2018) viewed that gap as the difference between the current situation and the desired situation, which can be reduced by building knowledge and gathering resources.

It is also important to draw a distinction between task complexity and task difficulty. In Wildemuth et al.’s (2014) analysis, task complexity attributes are a feature of the task itself, while task difficulty is defined by the relationship between the task and the performer of the task. This is to say that if the task does not contain the features of a complex task, but it is outside of the knowledge domain of the person completing the task, the task would be defined as simple and difficult. It should be noted that not all scholars take this view. Hærem et al. (2015) believed that the context of the task is inseparable from the task itself, and as such, the complexities of the context are inherited into the task. This is to say that task complexity can be affected by the physical setting in which it is performed. This concept could also be extended to include the device or Internet environment in which the task is performed. For example, if a task requires the task performer to utilize a piece of technology that is necessary for task completion but irrelevant to task outcome, then there is added complexity due to the context.

In the context of creative tasks, a key feature of task complexity may be goal factors. Both the number of goals and the certainty of goals can affect the task complexity (Bonner, 1994; Liu & Li, 2012). Bonner (1994) chose to use the term output instead of goal even if they are functionally similar (Liu & Li, 2012). Goal uncertainty may be a key factor for creative activities due to the subjective nature of the creator's interpretation of the task. An additional uncertainty factor is that as tasks become more complex, the learner's ability to correctly assess task difficulty and their own task outcome success has been noted to decrease (Singer et al., 2012). Uncertainty may even be necessary for searching tasks because lack of clarity may be a motivating factor for the learning to initiate information seeking (Kulhthau, 2004). Without the uncertainty of complex tasks, learners may not be engaged enough to seek information in an exploratory search. Indeed, the need to address gaps in knowledge can itself be a motivator, especially within a larger community (Scardamalia & Bereiter, 2010).

As task complexity changes so too can search behaviour. For instance, Byström & Järvelin (1995) found that as task complexity increased, the volume of sources used increased, the information found became more generalized, and the amount of success decreased. In other words, the participants searched for information from a wider variety of sources and were less successful in their attempts to find information. Higher task complexity may also be linked to longer first query times, more queries, and more words per query (Walhout et al., 2017). Similarly, complex tasks have been linked to longer queries and more varied search strategies (Wildemuth et al., 2018). However, there is also contradictory evidence that increased task complexity may cause fewer words per query, which could suggest that it may be more worthwhile to examine query changes in terms of generalizability instead of length (Saastamoinen & Järvelin, 2016).

It is important to understand the factors of task complexity because they can affect both the cognitive processes of the person doing the task, but also their interest in the task. For example, the authenticity of a task can increase task complexity because authentic tasks can feature complex interactions with numerous complexity factors (Saastamoinen & Järvelin, 2016). To summarize, while the true nature of the effects of task complexity remains somewhat ambiguous, complex tasks seem to rely on uncertainty in both goals and outcomes, which requires to learner to set their own goals based off of their own prior experience (Kuhlthau, 2004) or incomplete information at hand.

Constructionist Task Design

Because the research process is a process of locating, evaluating, synthesizing, and presenting information rather than just information retrieval, there is a constructivist learning process at play where the learner approaches the research problem by activating prior knowledge (Kuhlthau, 2004; Vygotsky, 1980). As the learner gets older, they have more prior knowledge and experience to draw upon (Knowles et al., 2005). When attempting to develop software skills, Mirel (1998) noted that software instruction needs to be suited to the social and cultural context of the learner. This is to say that the instruction should be situated somewhere within the learner’s knowledge domain to connect software options to practical outcomes. When generalizing this concept to include digital skills development as opposed to software skills development, it may be useful to avoid one size fits all skill development instruction by connecting it to professional or personal contexts of the learner (Lave & Venger, 1991).

Constructionism (Papert, 1993) is a constructivist learning theory that emphasizes creation and reflection. In constructionism, learners are encouraged to create learning objects that engage their interests and then reflect on the object they created. Constructionist learning activities rely on the activation of higher order learning skills (i.e., analyze, evaluate, create) as defined by Bloom's revised taxonomy of educational objectives (Anderson & Krathwohl, 2001). By allowing the learner to be the creator of the learning object, the learner is better able to rationalize their decision-making process and understand the outcomes of their decisions. In short, a constructionist task is based on constructing a learning object and, in the process of making the object, constructing understanding of that object.

By incorporating constructionist theory into an exploratory search task, researchers may be able to uncover cognitive processes that occur during the learning task by the participant post-task reflection. Researchers can help ensure higher levels of engagement with their research tasks by requesting that participants exercise creativity in the design of their learning object (Wildemuth et al., 2018). There is also evidence that significant differences between search behaviours tend to occur between low cognitively complex tasks and creative tasks, but not nearly as much between low cognitively complex tasks and evaluation/analysis tasks (Kelly et al., 2015). Thus, if a researcher wishes to achieve the most variance between low and high complexity tasks, or if they just wish to promote high levels of engagement with the search task, tasks that utilize constructionist principles seem to provide the most effective results.

Authentic Tasks

Authentic tasks mark an intersection between the concepts of task complexity and constructionist task design, sharing many of the same elements of these two concepts. For example, like complex tasks, authentic tasks are ill-defined, have multiple solutions, and multiple outcomes; and, like constructionist tasks, they provide an opportunity for reflection or in-the-moment assessment (Herrington et al., 2006; Young, 1993; Sokhanvar et al., 2021). However, Herrington et al. (2006) also incorporated several additional factors into their definition. In their view, authentic tasks allow for collaboration, occur over long time periods, and are not constrained to a single knowledge domain. Finally, they considered authentic tasks to be an important learning tool because they can synergize the learner and the task with technology. Using these defining characteristics, authentic tasks can be used to develop skills that are transferable across contexts (Young, 1993), which can also help develop lifelong learning skills (Alt & Raichel, 2020).

Digital Skills

The literature provides varying classifications of the skills required to work in technology rich environments. Differences between the skills classifications need to be untangled, but it should be noted that the terminology varies, which can make it difficult to compare studies on digital skills (Scheerder et al., 2017). For example, these skill sets, or subsets of these skill sets, have been called information and communication technology competencies (Desjardins, 2005), Internet skills (van Deursen & van Dijk, 2010) or digital literacy (Eshet-Alkalai, 2004). Each of these skillset frameworks interconnect to and overlap with each other in various areas, but there are some major differences in their scope and requisite sub-skills.

Desjardins' (2005) competency definitions are split into four orders. Broadly speaking, the orders of competency are defined below.

1. The technical order – constituting the skills needed to operate technological devices.
2. The social order – constituting the skills needed to interact between social actors across devices.
3. The informational order – constituting the skills needed to execute searches, organize, and write a variety of documents in various formats.
4. The epistemological order – constituting the skills needed to problem solve and utilizing the customization of software to work within one's domain.

van Deursen & van Dijk (2010) proposed a similar set of skills aimed specifically at digital skills in relation to the Internet. Their skills groupings are defined below.

1. Operational Internet skills – The skills needed to operate Internet browsers, search engines, and forms.
2. Formal Internet skills – The skills needed to navigate and orient oneself in an Internet browser.
3. Information Internet skills – The skills needed to define problems, select information, and evaluate information.
4. Strategic Internet skills – The skills to plan and execute larger strategies towards reaching a defined goal.

Interestingly, though van Deursen & van Dijk's (2010) proposed framework was designed to describe digital skills in an Internet context, they do not describe any social skills. This seems like an oversight due to the social and communicative nature of the Internet that is captured in Desjardins' (2005) orders of competency. They also do not account for document creation, which the other digital skill frameworks do. Though not explicitly labelled as internet skills, Hargittai (2007) proposed a similar framework that also accounts for social internet skills related to privacy (who can see one's online presence) and security (how can one avoid divulging sensitive information). Finally, it should be noted there is some difference in the definition between skills and competency. Skills typically encompass measurable individual abilities while competencies describe more generally the ability to apply skills in various contexts (Iordache et al., 2017).

Digital literacy is also sometimes considered to be synonymous with 21^{st}-century skills (van Laar et al., 2017). These terms typically describe competencies based on information management and communication, and they are often considered to be separate from information and communications technology (ICT) skills (van Laar et al., 2018). These skills can be facilitated through the use of digital technology and the Internet, but do not describe the ability to utilize technological devices. For example, problem-solving is not an ICT skill in and of itself, but ICT skills can help facilitate one's problem-solving abilities. It is unsurprising then that the term 21^{st}-century skills has attracted criticism because a number of its constituent subskills (e.g., social/interpersonal skills, problem solving) have been relevant long before the advent of digital technologies (Kirschner & Stoyanov, 2020). As a result of that contention, these authors tend to reduce the term to include only information literacy and information management.

Another view for framing digital skills then is to separate them into core skills (e.g., technical, informational, and problem-solving skills) and contextual skills (e.g., ethical, cultural, and self-direction skills) (van Laar et al., 2017). Eshet-Alkalai (2004) identified multiple forms of digital literacies in similar manner that range from describing how users interact with information to how users interact with social realities of online communication. For example, Eshet-Alkalai used the terms “branching literacy” to describe understanding of the non-linear nature of hyperlinked text and “information literacy” to describe understanding of the issues of credibility and integrity in online environments, which align with the informational nature of a core skill. However, the author also used the term socio-emotional literacy to describe the social skills needed to identify hoaxes, spam, or real individuals in chat rooms or emails, which is similar to a contextual skill. This model suggested that while some digital literacies may have existed prior to digital technology, they may not be completely transferable to digital environments.

A well-known construct for viewing digital skill aptitude is the concept of digital natives and digital immigrants (Prensky, 2001), which describes those whose lives have been immersed in technology (digital natives) and those whose lives have not (digital immigrants). Prensky argued that digital natives require different forms of education than digital immigrants. However, this argument ignored the possibility that digital skills can be affected by multiple factors, including “socio-economic status, cultural/ethnic background, gender and discipline specialization” (Bennett et al., 2008, p. 5). Research also suggests that we should not assume that digital technology immersion is equal across same-age student populations or that all activities are equal for developing digital skills (Bennett et al., 2010). Kirschner & van Merriënboer (2013) provided three warnings when making assumptions about the digital skills of young adults (i.e., university students).

1. Prolonged exposure to digital technologies and the Internet does not necessarily equate to strong digital skills.
2. When given control of a learning task on the Internet, learners tend to avoid developing new skills in favour of doing what they already know how to do.
3. Learners have difficulty determining what they don't know, which can lead to difficulty overcoming barriers when they arise.

Indeed, evidence of warnings 1 and 2 have been seen in more recent studies as well. Working professionals in creative industries reported mediocre digital skills overall while also avoiding goals that the participant is afraid of performing poorly (van Laar et al., 2019). The same study noted that self-employed individuals did not avoid such goals as readily as employed individuals did, which could suggest that self-regulated learning skills can play an important role in digital skill development. While many studies on digital skills are performed in a professional context, it may be useful to explore the differences between other social and cultural contexts to determine how digital skills are best developed (Scheerder et al., 2017).

Computer Self-Efficacy or Computer Confidence

The self-efficacy theory, as it relates to learning activities, is a cognitive theory that describes relationships between individual's belief in their own abilities to complete an activity and their actual performance in said activity (Bandura, 1977). In other words, individuals with high self-efficacy tend to be more motivated and more likely to express resiliency when encountering barriers while individuals with low self-efficacy are less motivated and more likely to give up when barriers are encountered. The concept of self-efficacy has since been used in the context of computers and computer-based learning under the term Computer Self-Efficacy (CSE) (Moos & Azevedo, 2009; Jan, 2015; Karsten et al., 2012) to describe an individual's belief in their ability to utilize digital technology.

As mentioned above, it should not be assumed that students with lots of computer experience possess strong digital skills (Kirschner & van Merriënboer, 2013). Likewise, in a study comparing computer self-efficacy across a 10-year time frame (2004 – 2014), there was evidence that the student population from 2014 expressed lower self-reported proficiency than the 2004 group (Clayton et al., 2017). However, there is also evidence that increased computer usage can lead to higher computer self-efficacy (Cocoradă, 2014; Cussó-Calabuig et al., 2018; Schlebusch, 2018), which suggests that more contextual data may be needed to understand factors that affect CSE. These contextual factors may be related to the same contextual factors that can influence digital skill development as discussed in the Digital Skills section of the Literature Review. For example, there is evidence that CSE differs across genders, with females reporting lowers CSE scores than males (Cussó-Calabuig et al., 2018; Bao et al., 2013), but these findings are not reliable across multiple studies (Jan, 2015). In a review of CSE in teenagers across nine studies, females reported lower CSE and higher computer anxiety than males (Cussó-Calabuig et al., 2018). Due to the conflicting evidence on the gender gap in CSE, it may be worth examining demographic category combinations for more reliable data.

Computer efficacy often goes hand in hand with computer anxiety (Cussó-Calabuig et al., 2018; Venkatesh & Morris, 2000). Lowering computer anxiety and increasing computer self-efficacy are important factors for developing computer skills (Schlebusch, 2018). Low self-efficacy can also affect the information seeking process, causing the information seeker to give up or be unwilling to change their strategy for something new (Savoleinen, 2015). Thus, there is a tension where low computer self-efficacy can be associated with computer avoidance, but computer self-efficacy can also be raised through increased computer access. To bridge the gap, it may be useful to find ways for learners to engage with computers in situations that do not cause much anxiety.

Computer self-efficacy measurements do not necessarily need to be restricted to a single software application. For example, there is evidence that self-efficacy measurements in one software application can be generalized to other, similar software applications (Johnson et al., 2016). Similarly, general CSE (i.e., non-application specific CSE) has been found to positively influence specific CSE (i.e., CSE within a specific software application) (Bao et al., 2013). This would raise the question that if one aimed to raise computer self-efficacy, could allowing learners to complete activities on the software of their choice raise their confidence levels in other software they perceive as similar? For these reasons, computer self-efficacy should be considered when designing research tasks to avoid situations where participants may prematurely give up before task completion.

Self-Regulated Learning

According to Zimmerman (1990), self-regulated learning behaviour can be defined by three key constituent subskills: metacognition, motivation, and behaviour.

Zimmerman suggested that self-regulated learners exhibit self-awareness of their own abilities, persistence in their efforts, intrinsic motivation, and an ability to structure personal environments conducive to learning. Self-regulated learning is closely tied to the theory of self-efficacy (Bandura, 1979) since self-regulated learners tend to exhibit high self-efficacy (Zimmerman, 1990). Additionally, self-regulated learners have the ability to identify what they do not know and develop strategies to address that gap in knowledge, which is a skill rarely exhibited among student Internet searchers (Kirschner & van Merriënboer, 2013).

It should not be assumed that technology rich environments inherently produce more student engagement with learning activities (Schoenborn et al., 2013). Instead, self-regulated learning skills, particularly meta-cognitive skills, are considered to be an important driver of digital literacy (Anthonysamy et al., 2020). This is to say that digital skills may be better developed through development of self-regulated learning skills than by technological immersion. Self-regulated learning and self-assessed activities also align closely with the concept of life-long learning (Alt & Raichel, 2020), which is to say that these are skills based on understanding gaps in current knowledge and the motivation to address those gaps.

Study Framework

Based on the literature review above, this study positions the research process and the Internet as learning environments or components within learning environments. In other words, the research process and the Internet are contexts in which the act of learning can occur. This study aims to generate engagement with the learning environment through participation in complex research and creation tasks, thus defining another learning environment: document creation software.

Task complexity can be achieved using the principles of constructionism in the task design. By utilizing a constructionist study task, participants can potentially engage in creative thinking (Anderson & Krathwohl, 2001), which leads to uncertain outcomes (Campbell, 1988), allowing participants to draw upon their own experiences to inform their learning (Knowles et al., 2005; Vygotsky, 1980). This study does not aim to measure the effectiveness of the task design on computer self-efficacy of the participants. Rather, the framework of this study assumes that a constructionist task can help limit the effects of low computer self-efficacy and increase the likelihood that participants will complete the study task.

This study utilizes a "work backwards" model of skills development whereby participants are introduced to the learning task through a creative and informational research problem in an open Internet environment. It is "work backwards" on two levels. The first level is that technological skills are typically considered base level skills for computer usage (Desjardins, 2005; van Dijk & van Deursen, 2010). In the format that digital skills frameworks organize their skills, the technological component typically comes first. However, if the learner is sufficiently engaged in the information problem-solving component of a task, they may be increasing their exposure to technological concepts and skills that they may not have developed prior. In other words, this study aims to see if utilizing an information task can help to introduce new technological skill processes required to achieve information management outcomes.

The second level is that the task is goal oriented, and the learning task was created by addressing barriers to the learning outcome identified in the research. This is consistent with the concept of backward design in curriculum development (Wiggins & McTighe, 2005). By removing barriers and promoting behaviour associated with the learning outcome, this study anticipates that the task can be focused on specific learning goals.

The purpose of this framework is to test if technological skills can be developed through the incorporation of three major factors that mitigate barriers to technological skill development:

1. Promoting engagement with technology through an authentic informational research task.
2. Promoting the usage of higher order cognitive processes through a creative and reflective learning task.
3. Mitigating the factors that can cause learners to prematurely abandon learning activities.

With this framework (see Figure 1), this study aims to investigate how technological skills can be developed by the learner as they attempt to work through the informational task. This study works under the assumption that informational skills are not strictly tied to digital skills. By providing an information task in a digital environment, and requiring learners to create something with that environment, participants may be forced to problem-solve through technological barriers to achieve informational outcomes.

Figure 1 – Study Framework

Construction Task and Research Process		
Task Characteristics	**Effects on Learner Behaviour**	**Learning Goal**
Exploratory Research Task	Increases Engagement in Learning Problem	Technological Skill Development
Constructionist Task	Increases Engagement with Technology	
Technologically Rich Environment	Decreases Effect of Low Computer Self Efficacy	

Method

Study Design

The design for this study was based on the framework proposed in the previous section. The constructionist, information problem task, as recommended by the framework, made up the bulk of the data collection period. Additional pre- and post-task survey/questionnaire data collection was added to help contextualize and understand the data generated during the task. The proposal for this study included 2 data collection phases, listed below:

- Phase 1 – A pre-task survey to assess the demographic data and the digital competencies of the participant population.
- Phase 2 – A one-on-one live session, in which the researcher observed as the participant completed a construction task in an Internet-based environment, followed by a post-task questionnaire designed to allow participants the opportunity to reflect and report on the object that they created during the live session.

Separate consent letters were written for each phase so as to provide information relevant only to the specific phases. The Phase 1 consent letter was provided prior to the participation of the Phase 1 survey. Once the Phase 1 surveys were completed, participants could read the Phase 2 invitation and consent letters to determine if they were interested in continuing their participation.

After reading the Phase 2 consent letter, participants could input their email address into a field at the bottom of the page to provide their consent to continue. Participants were then contacted via email to arrange a mutually acceptable time to complete the one-on-one live session. To reduce the amount of back-and-forth emailing, participants were provided with a schedule of session slot times and were requested to respond with three slots ranked in order from most convenient to least convenient. The researcher would then schedule a session using the most convenient available time.

The Phase 2 task was presented as an information problem with a technological component (see Appendix A1). Participants were asked to create a professional looking brochure for Ripley's Aquarium of Canada. They were provided with links to the Ripley's aquarium website and two example brochures. A couple decisions and tensions had to be addressed during the task design. Firstly, although the problem was an information problem, technological skill development was the goal of the study. This meant that the study design should provide ample opportunity for creation during the task. Additionally, since the task was to be timed, participants needed to be given enough time to begin creating their brochures.

The study was designed to be measured on two digital competencies: informational and technological (Desjardins, 2005). This meant that there may have been two levels of complexity to address in the task. The decision was made to provide initial materials in the task instructions because these materials were for the most part information materials, which could allow the participants more time to focus on technological barriers to creation should they arise. However, there is some risk in providing existing materials to participants. For example, providing information about the task topic could reduce opportunities for learners to identify information needs, which may be important for initiating information seeking behaviour (Kuhlthau, 2004; Borlund & Ingwersen, 1997). Beyond this, Young (1993) argued that learners should be able to create both problems and solutions and that providing too much structure to a task could lead to learners following a small number of pathways. While some structure was provided in this task, it was decided that there were still opportunities for participants to assess and prioritize information, encounter barriers in software functionality, and personalize the learning object.

Participants and Recruitment

Participants were students recruited from business programs in two local Ontario Colleges, which will be referred to as College 1 and College 2. Recruitment was conducted via email by administrators at each of the colleges. This participant population was chosen due to its proximity to the workplace, as many potential participants would be young adults in two-year diploma programs, who would likely require technological and informational digital skills for their careers.

Participants from College 1 were recruited on May 17, 2021, and live sessions for these participants were conducted from late May to mid-June. Participants from College 2 were recruited on July 14, 2021. A follow-up recruitment email was sent out on July 26 due to a low number of responses. Live sessions for College 2 participants were conducted in late July. Participants who continued on to the Phase 2 live session of the study were entered into a draw for one of two iPad Airs. The draw for the winners was conducted in September 2021.

The following information on the student populations of the chosen Ontario Colleges is from the Ministry of Advanced Education and Skills Development College Enrolment Statistical Reporting system (Ministry of Colleges and Universities, 2021). College 1 had 24,351 students enrolled in full-time programs in the Fall semester of 2019-2020. 52.5% of those students were female and 47.3% were male. The remaining 0.2% did not disclose their gender. College 2 had 11,666 students enrolled in a full-time program in the Fall semester of 2019-2020. 48.6% of those students were female and 51.2% were male. Again, the remaining 0.2% did not disclose their gender.

While the preceding data provides a useful overview of the respective college student populations, there are some caveats. Firstly, this demographic data is from Fall semester full time program enrollment, but this study was performed during the Summer semester, which typically has lower enrollment numbers. Secondly, these numbers are from the 2019-2020 academic year, but this study was performed in the 2020-2021 academic year. This means that while there is confidence in the general accuracy of these numbers to represent the student population at the time of the study, they are not exact. Finally, the enrollment numbers in the 2020-2021 academic year likely were affected by the COVID-19 pandemic. The numbers provided in the above paragraph are representative of fall, 2019, which was prior to the campus closures in March 2020. An additional factor relating to the COVID-19 pandemic is that many potential participants would not be in Canada during the data collection phase 2 due to international travel restrictions.

Fifty-one participants that completed Phase 1 of the study provided their consent to be contacted for Phase 2. Of those, 17 participants arranged a session time. Eleven participants completed a session, one attended but withdrew prior to session completion, and five did not attend their scheduled sessions. This means that approximately one in five contacted participants completed the study.

Due to a catastrophic data loss on EILAB servers, all demographic data for College 1 participants were lost. College 2 participant demographics were retained, but they comprised a smaller proportion of the overall data set. Demographics for participants from College 1 that attended a live session were recreated to the best of the researchers' ability.

Study Context

Participants performed the task in the physical environment and used the devices of their choosing. There are positives and drawbacks to this study approach. The setting and computer of the participants' choice adds a layer of authenticity to the task environment (Herrington et al., 2006), but it can also add levels of complexity to the task (Hærem et al., 2015). Additionally, since participants were able to use their own device, a variety of different devices was to be expected, including mobile devices. Although phones were unlikely to be used, tablets were a possibility. However, the usage of mobile devices also represented an opportunity to add to the comparatively understudied area of digital skills in mobile devices (Blayone et al., 2018).

Some anticipated complications due to the remote nature of the study included: noisy backgrounds, additional persons appearing on camera if the webcam is on, outside factors diverting participant attention, and inconsistent Internet connections. Some of these complications did occur during the sessions, but no major disruptions occurred.

Data Collection Tools

The Phase 1 pre-task survey was conducted via the Digital Competency Profiler (DCP) through the use of the Global Readiness Explorer (GREx) provided by the EILAB at Ontario Tech University (EILAB, 2017). The DCP is a survey designed to assess digital competencies. Each question in the survey is mapped to one of four competencies (technical, social, information, epistemological) as defined by Desjardins' (2005) GTCU framework. See Appendix C for a list of survey questions and their associated competency. Each DCP question measured the both the frequency and confidence of usage in the described activity for each participant.

The GREx is a dashboard that can be used to deliver the DCP and other surveys. The consent letters and DCP survey were presented through this dashboard. A group can be established in the GREx dashboard for the collection of data from the participants at https://grex.eilab.ca/. Once participants logged into the GREx with a valid email address, they were given access to the demographics survey. After the demographics survey, they were able to access the DCP and the Phase 2 consent letter.

The Phase 2 live sessions were conducted via Google Meet and were recorded with Open Broadcast Software (www.obsproject.com) because Google Meet recording options were locked behind permissions not available to the researcher. The participant's computer screen and voice were recorded along with the researcher's voice. At the beginning of each session, the participants were read a consent script and asked to verbally re-affirm their consent. After verbal consent was obtained, the researcher explained the task and allowed the participant to ask questions before beginning.

Once the session task had begun, the researcher's microphone was muted unless a question was directed to him. The participants were able to turn on their webcam if they chose to do so, but it was not required. If a participant had their webcam on, it was recorded. Since participants were sharing their screen during the session task, they would not have been able to see the researcher during the task unless they were utilizing a dual monitor setup. During the task, participants were asked to use a Guest profile on their Internet browser. This was done for two reasons. The first was to protect the privacy of the participants so that their previous browsing history would not be auto-suggested by their browser during the session. The second was to prevent the participant's browsing history from interfering with their search processes. The live session recordings were analyzed using Noldus The Observer XT 14, which is a behavioural coding software.

The Phase 2 post-task questionnaire was to be conducted via LimeSurvey, which is an open-source survey creator tool. However, no actual data were collected via LimeSurvey for two reasons. The first reason was related to the catastrophic data loss on the EILAB servers. This event, which coincided with the College 1 live session data collection period, required all data collection tools hosted on the EILAB servers to be unavailable until they were rebuilt. The second reason is due to an error committed by the researcher during the questionnaire setup, which caused all College 2 participant responses to not be saved. Due to an error in survey set-up, two participants were asked to complete their post-task questionnaire two weeks after they completed their live session. As a result, all post-task questionnaire data was collected via a Word document version of the questionnaire, which was sent to and returned by the participants via email.

Procedure

After the participants completed the DCP and demographic survey, they were given the option to continue their participant in Phase 2 of the study, which was a live session with the researcher. The live session task was based on Papert's theory of constructionism (1993) and Marchionini's model of exploratory searching (2006). Participants were given 60 minutes to create a brochure on a tourist destination (Ripley's Aquarium of Canada). They were encouraged to use, but not limited to, Microsoft Word to create the brochure. They were also instructed to use the Internet to help them create the brochure. Participants were instructed to think-aloud their thought processes while working on the task. See Appendix A1 for a copy of the task instructions. Once the task was completed, participants were asked to complete a post-task questionnaire that allowed them to assess or report 1) their satisfaction with the brochure they created in terms of usefulness and professionalism, 2) any skills they may or may not have developed, 3) barriers they may or may not have experienced, and 4) the appropriateness of the time frame to the task.

As stated before, the live session with the participants utilized a think-aloud methodology (Ericsson & Simon, 1980; van Someren et al., 1994), in which the participants are asked to verbalize their thoughts while performing the study task. This method was chosen because it helps ease issues of trustworthiness (Guba, 1981) by providing multiple and rich data sets (observed actions and vocalized thought processes) for triangulation. This method also allows for information to be verbalized without the interference of retrospection, which may affect how the participant views any particular action or situation (Ericsson & Simon, 1980). It is recommended when designing think-aloud tasks to strike a balance between tasks that are too cognitively demanding and tasks that are too simple (Charters, 2003). A task that is too demanding can interfere with a participant's ability to verbalize, but a task that is too simple may not stimulate the participant into saying anything of value. Additionally, it is recommended that participants be given an opportunity to practice thinking aloud through the use of a preparation or primer activity (Gibson, 1997; van Someren et al., 1994). Primer activities can also help the researcher remove participants who are unable to produce satisfactory verbal data (van Someren et al., 1994). However, due to time constraints during the data collection phase of the study, primer activities were not performed. Most participants had to be prompted at least once near the beginning of their task to encourage vocalization.

There are also issues of prompting and bias when applying and designing tasks for think-aloud methods. The researcher should attempt to avoid interference wherever possible (van Someren et al., 1994). However, if the participant is not producing sufficient verbal data or is silent for an extended period of time, the participant may be prompted, or encouraged, to keep talking. This can be done via verbal reminders (van Someren et al., 1994) or by utilizing a sign with a written reminder to keep talking (Gibson, 1997).

Wherever possible, the researcher avoided speaking or interfering during the sessions. When participants were silent for extended periods of time, the researcher would encourage them to continue by either saying "keep talking" or asking, "what are you thinking right now?" Sometimes participants were silent for extended periods because they were reading, which may have interfered with their ability to think-aloud. Additionally, most participants asked questions of the researcher during the sessions. In cases where participants were seeking direction from the researcher, they were encouraged to use their own judgment. In a few cases, the researcher had to interrupt the participant due to low batteries or accidentally muted microphones, which had the potential to interfere with the sessions.

Data Analysis

Credibility, Transferability, and Dependability

During the live session portion of the study, data were collected from four sources: the video analysis of participant activity, the transcript of participant think-aloud dialogue, post-task questionnaire Likert scale response, and the written reflection responses for each post-task questionnaire item. The breadth and quality of the data allows for a thick description of and triangulation for any claims made in this analysis.

Notes were taken during the process of video analysis to help enrich the quality of the observations over multiple periods of time to help establish credibility of the findings through prolonged engagement (Guba, 1981). Though the level of generalizability in this study is unknown due the unique location and work habits of each participant, the descriptions provided of the participant activity should help readers understand the context in which the study took place. Half of the coding scheme used to analyze the video recordings was also verified by an independent coder to help establish the dependability and reliability of the findings.

Initial Coding Scheme Creation

The initial coding scheme for video data analysis was based on a synthesis of frameworks by Desjardins (2005), van Deursen & van Dijk (2010), and Brand-Gruwel et al. (2009). Each coding scheme element was assigned to be a demonstration of either technological or informational skills as seen below in Table 1.

Table 1 – Initial Skill Definition Coding Scheme

Digital Skill Definitions (Version 1.0)	
Technological	**Informational**
Navigating between web pages	Defining problem
Entering search keywords	Defining queries
Navigating menu and option screens	Evaluating information
Entering parameters for built-in software functions	Using software options with a purpose
Playing video and using playback controls	Maintaining orientation in exploratory search
	Applying located information in task software environment

Over the course of video analysis, the codes were divided under four umbrella categories: research actions, barriers in problem solving, technological skill demonstrations, and informational skill demonstrations. The video data was coded in three passes. The first pass prioritized technological skill demonstrations, the second pass prioritized informational skill demonstrations, and the third pass prioritized barriers and regulatory skills while also serving as an opportunity to review and re-assess the previous two passes. Multiple changes were made to the coding scheme at the beginning of pass one, after pass one, and after pass two. The change logs can be viewed below in Table 2.

In most cases, the changes to the coding scheme were to account for anticipated behaviour that did not occur during the study sessions or to account for unanticipated actions by the participants that were not covered in the coding scheme. Some changes were also made to reduce redundancy in the coding scheme. An example of the former would be that the use of video controls only occurred once in all the sessions and as such did not need to be accounted for. More informational codes needed to be added to account for the types of behaviour that occurred during the sessions. The two most notable codes added were exploring or reading information and evaluating information. Adding another code to account for split screen environments was another important change. This was added because it was difficult to determine based purely on the location of the cursor and the think-aloud vocalizations about which environment the participant was working in.

Some code revisions were also made for clarity and usefulness. For example, navigating menus and clicking software had clarifying statements added to them because there were instances of multiple interpretations of these actions based on the previous wording. In the early wording, navigating menus did not account for the fact that sub-menus could occur within another menu. This was clarified to count a single menu navigation chain as a single menu navigation action. Additionally, when clicking options, participants could click on a single button multiple times in the attempt to perform one action. This could be seen when a participant would click the plus or minus buttons on a slider. Additionally, participants would often click on an option for a sub-menu within a menu. Since this was already accounted for by the new menu options, the clicking options code only needed to account for actions that did (or would) apply to the document.

Table 2 – Coding Scheme Change Logs

Version 1.1

Video tools removed from technological skills

Added moving/repositioning/resizing/deleting objects (text boxes, shapes, images, etc.)

Separate codes added for transition to and from document creation environment

Navigating and clicking options re-worded to include sliders

Version 1.2

Combined Navigation of Internet and clicking links into a single code called "Internet Actions"

- Internet Actions includes opening tabs, closing tabs, changing tabs, clicking links, closing pop ups

Combined typing search keywords and creating queries into a single code called Query Actions.

- Query actions moved to be under the Research Actions umbrella

Internet actions have been redefined to be called Research Actions

- Research Actions can occur in either work environment

Navigating Menus has been clarified to say that an instance of this event can include multiple clicks of navigation and ends when the act of navigation is over

Clicking software options has been clarified to say that it doesn't take effect until the action has been applied to the document

Separating online information application into two categories

- The first category is for copying or pasting text or images
- The second category is for paraphrasing information

A third environmental category has been added to account for periods of time where the participant is using a split screen

Deleted using software options with a purpose because the terminology is vague and difficult to measure

Changes to Informational skill codes have been redefined for the purposes of feasibility and clarity. Codes may require the judgment of the rater and/or robust vocalization data from the participant.

- Code added for reading or scanning information
- Code added for evaluating information and selecting information
- Code added for inserting, or copying and pasting, or typing information verbatim
- Code added for modifying or paraphrasing information
- Code added for visualizing information
- Maintaining orientation has been rephrased to losing orientation since it will be coded via comments on being lost
- A regulation activity has been added to account for commentary about keeping oneself focussed on the task at hand

Version 1.3

Paraphrasing or modifying information adjusted to include typing information

Inter-Coder Reliability

An independent coder was recruited to ensure the reliability of the coding scheme in practice and the trustworthiness of the data. Inter-coder reliability was established over two video coding sessions in Noldus The Observer in which the independent coder coded a session pre-prepared by the researcher. The sessions were pre-prepared by creating a new observation within the research project that had observation start and stop times already established. Each session was followed by a meeting to discuss differences in interpretation and application of codes.

Only the coding scheme and an early draft of the methodology section of this thesis was provided to the independent coder to avoid unnecessary influence as to the interpretation of coding scheme items. Only code groups 2 and 4 were included in the process because they required more subjective interpretation of participant activity. Several key differences in coding scheme interpretation were identified during this process. These differences were resolved and are listed as follows:

1. Changing fonts and font sizes constitutes visualizing information
2. Time spent copying, pasting, or inserting information does not constitute evaluation of information. Though it may be implied that the participant finds the information useful by selecting it, it cannot be established that they are evaluating it during the selection process if there are not corresponding vocalizations that corroborate their actions.
3. A code should be applied each time a participant copies or pastes information. Using a single code to capture the copy and pasting process does not capture

events where a participant may display patterns such as copy-copy-paste or copy-paste-paste, for example.

4. Loading times do not constitute pauses in task performance because they are largely outside the control of the participant. No code should be applied during these instances.
5. Vocalizations that establish or re-iterate short term goals are regulation activities.

Once these differences were resolved, any still existing differences in the application of the coding scheme were few in number and minor in disagreement. These differences were resolved either because they could either be attributed to a mistake by one of the coders or minor differences in the start and stop times set by either coder. After the second round was completed, the remaining differences were discussed and mediated, and it was decided that no further rounds were needed. This process helped ensure that the coding scheme was robust and validated.

Final Coding Scheme

Once the revisions determined by the inter-coder process were applied, the final coding scheme was set as follows (see Table 3). Coding scheme elements were defined as either point- or state-based events in Noldus The Observer XT 14. Point based events measure the frequency of an event, but do not contain durations. State based events do have durations, so the frequency and duration of these events were measured. Only one state-based event was active at any given time so preference was given to the most relevant state in situations where two or more states could apply. Typically, the states were applied using the following hierarchy in Table 4. For example, defining a problem always took precedence over any other activity. If a participant was in the middle of another activity (such as reading, evaluating, or visualizing) and began the act of defining the problem, the current activity would be paused in the event data to allow the defining problem event to occur.

Table 3 – Final Skill Definition Coding Scheme

Code Category	**Code Definition**	Code Sub-Behaviours
Code 1	**Research Actions**	
		Query actions
		Transition to document creation environment
		Transition to research environment
		Split screen environment
Code 2	**Barriers in problem solving**	
		Pause in task performance (Inaction or repeated actions with no discernable purpose or effect)
		Vocalization of uncertainty
Code 3	**Technological skill demonstrations**	
		Internet actions (clicking links, navigation between tabs, new tabs, closing tabs)
		Navigating menu and option screens (instance ends when act of navigation is over)
		Entering parameters for built-in software functions
		Clicking software options/using sliders (doesn't apply until option is applied to documents
		Moving/repositioning/resizing/deleting objects (text boxes, shapes, images, etc.)
Code 4	**Informational skill demonstrations**	
Define information problem		Defining problem (Comments on defining problem)
Search Information		Defining queries (time spent formulating searches)
		Exploring or reading information (time on page, scanning, reading aloud)
Evaluate information		Evaluating information (e.g., comments on usefulness, quality, or trustworthiness)
Applying information		Inserting, copying, pasting, or saving information
		Typing, paraphrasing, or modifying information
		Visualizing information (time spent adjusting visuals/layout of brochure, organization)
Regulatory Skill (Brand-Gruwel et al., 2009)		Losing orientation in exploratory search (comments on being lost)
		Keeping oneself on track, Regulation (comments on distraction of losing focus)

Table 4 – Hierarchy of State Based Events

Tier	Event
1	Defining problem
2	Defining queries; Evaluating information
3	Exploring or reading Information
4	Typing, paraphrasing, or modifying information; Visualizing information
5	Pause in task Performance

Results and Discussion

Overview of Results and Discussion

Few major findings were uncovered through analysis of the data in relation to the research questions. However, the results of the discussion have prompted several emergent themes and uncovered recommendations for areas of future research. Discussion has been organized as it relates to each of the research questions. Some research themes overlap between the research questions discussed. As such, references to previous or pending discussions do occur. This analysis will begin by examining the demographic and digital competency information of the participant population in this study before addressing each research question.

Participant Population Demographics

Basic demographic information was collected for each participant (See Tables 5, 6, and 7). Some participants completed the demographic survey but did not complete the DCP. Additionally, some of the DCP data was retained after the data loss that this study experienced, but the corresponding demographic data was lost. As a result, the demographic tables were flagged as missing values because those columns were left blank in order to keep the DCP data in the analysis. This also means that some DCP analyses will have fewer completed data sets than the demographic tables would indicate.

Table 5 – Gender

Gender	Number
F	15
M	16

Note. Excluded 54 rows from the analysis that correspond to the missing values of the split-by variable Gender

Table 6 – Education Level

Education Level	Number
High School	8
College	4
Bachelor's	7
Master's	5

Note. Excluded 61 rows from the analysis that correspond to the missing values of the split-by variable FE

Table 7 – Age

Category	Valid	Median	Mean	Minimum	Maximum
Age	24	27	27.92	20	46

Participant Competency Analysis

Student t-tests were performed for each question and competency category in the DCP across three demographic variables: gender, education, and age. Parametric tests were used because they are more sensitive to differences in small sample sizes. This was necessary due to the incomplete demographic data in the survey results, which reduced the sample size. Each DCP question description and its associated order of competence can be found in Appendix C. Each question response was measured in both frequency and confidence of usage. Responses for both categories were analyzed in the following sections.

Competency by Gender

Equal variance cannot be assumed for multiple questions in both frequency and confidence of usage when comparing genders. For frequency of usage, there were two significant differences in a question set of 26 (see Table 8). This indicates that there are likely not significant differences between males and females in frequency of usage.

Significant differences were found in confidence of usage in questions 16, 17, 18 (see Table 8), which are associated with the informational order or competency. These three questions in particular refer to confidence in downloading movies, music, and books from the Internet, and they suggest that males are more confident than females in their abilities to download media from the Internet.

Table 8 – Frequency and Confidence by Gender

Question	**t**	**df**	**p**	**Gender**	**N**	**Mean**	**SD**
frequencyQ10	2.38	21	0.03[a]	F	9	3.89	0.33
				M	14	3.21	0.80
frequencyQ16	-2.14	21	0.05	F	9	1.33	1.00
				M	14	2.29	1.07
confidenceQ11	-2.62	21	0.02	F	9	3.00	0.87
				M	14	3.79	0.58
confidenceQ16	-2.97	21	0.01[a]	F	9	2.33	1.41
				M	14	3.71	0.83
confidenceQ17	-3.19	21	0.004[a]	F	9	2.89	1.05
				M	14	3.86	0.36
confidenceQ18	-2.19	21	0.04	F	9	2.33	1.32
				M	14	3.36	0.93
confidenceQ20	-2.19	21	0.04[a]	F	9	2.56	1.13
				M	14	3.58	0.63

[a] Levene's test is significant ($p < .05$), suggesting a violation of the equal variance assumption

When question results were aggregated into their respective competency categories, significant differences were found in social and informational order confidence of usage (see Table 9). Males were found to be more confident in both categories. This evidence suggests that although females in this sample likely do not use digital technology less frequently than males, they may be less confident in its usage, which is consistent with previous research on the subject (Cussó-Calabuig et al., 2018).

Table 9 – Aggregated Competencies by Gender

Competency	t	df	p	Gender	N	Mean	SD
Confidence Social	-3.05	21	0.006	F	9	23.11	3.14
				M	14	26.21	1.76
Confidence Informational	-2.68	21	0.01	F	9	19.78	3.73
				M	14	23.36	2.68

Competency by Education

Education level was divided into two groups: high school and postsecondary. No significant differences in frequency of usage were found between the two groups. Only one question reported a significant difference in confidence of usage (see Table 10), which reported that the high school group (M = 3.86, SD = 0.38) was more confident in using "other" devices (i.e., home entertainment system, thermostats, lights, etc.), $t_{(14)} = 2.49$, $p < .05$). This is not particularly meaningful when considering the broadness of the question. When aggregated, the high school group (M = 13.86, SD = 2.55) reported greater frequency of usage overall in technical competencies, $t_{(14)} = 2.72$, $p < .05$ (see Table 11). This would suggest that while the high school group utilizes technical competencies more often, they are not more confident in their usage.

Table 10 – Confidence by Education Level

Question	t	df	p	Education	N	Mean	SD
confidenceQ5	2.49	14	0.03[a]	High school	7	3.86	0.38
				Postsecondary	9	2.56	1.33

Note. Student's t-test.

[a] Levene's test is significant (p < .05), suggesting a violation of the equal variance assumption

Table 11 – Aggregated Competencies by Education Level

Competency	t	df	p	Education	N	Mean	SD
Frequency Technical	2.72	14	0.02	High school	7	13.86	2.55
				Postsecondary	9	10.89	1.83

Competency by Age

As noted earlier in this paper, technology usage behaviour has been reported to be highly variable across all ages (Desjardins & van Oostveen, 2015). Age differences were examined through multiple perspectives in this analysis, but no significant differences could be established in this population.

While this study does not aim to compare demographic variables among the participants who completed the phase 2 live session, it may be useful to capture a snapshot of the population from which those participants were recruited. In summary, males were found to be more confident in social and informational competencies in this population sample. Very little difference was found when separating by education and age. However, it is important again to recognize that the samples in these analyses are small and should be viewed with some skepticism when extrapolating it to be representative of the target population.

R1 – What significant correlations exist between construction and research task activities and self-reported post-task questionnaire results?

Before correlations between live session activities and post-questionnaire responses could be correlated, the live session data needed to be organized. Live session activities were broken down into state- and point-based actions. State-based actions have a start and stop time. The activities were measured by showing the total amount of time each participant spent in each state along with the total time they spent on their task. The amount of time each participant in each environment (research, document creation, split) was also measured. Point-based actions do not have durations. These actions were counted to show how many times each participant performed each type of action. Not every participant used the full 60 minutes, so both and state- and point-based actions then were adjusted on a per minute basis to facilitate comparison across participants.

State-based results

As a whole, participants spent most of their time reading, exploring, or visualizing information (see Table 12). Most participants spent very little time defining problems relative to other activities (3.4% of the total time as a group), which is consistent with the findings of Brand-Gruwel et al. (2009), despite the difference in task domain. Very little evaluation occurred across all participants. As seen in Table 12, every participant experienced a significant amount of "Blank" time. This is any time spent that could not be accounted for in any of the other codes. Often, this time included loading times, saving files, or asking questions of the researcher.

Table 12 – Time Spent per Minute – State-based Coded Activities (in seconds)

Participant	Defining Problem	Defining Query	Reading / Exploring	Evaluating	Typing	Visualizing	Paused	Blank
A2	2.79	1.07	18.91	2.41	5.40	16.49	6.42	6.51
A12	0.58	0.62	9.79	0.16	16.27	11.98	8.69	11.92
A13	1.23	0.66	13.89	0.19	1.07	16.77	12.55	13.64
A14	0.54	1.45	13.85	0.56	4.26	9.84	22.64	6.86
A18	3.37	0.52	13.30	3.65	0.00	26.19	5.82	7.13
A23	2.19	1.88	15.81	3.82	3.63	23.65	1.53	7.50
A24	6.50	0.72	30.81	2.48	1.84	2.06	5.70	9.89
A26	2.25	0.39	6.47	1.24	4.26	29.74	6.08	9.58
A33	1.76	0.18	24.43	1.86	2.86	11.44	2.41	15.06
A44	0.60	1.55	12.91	0.22	12.00	18.80	4.19	9.74
A48	0.66	1.05	10.99	0.68	2.02	29.98	2.52	12.09
Average	2.04	0.92	15.56	1.57	4.87	17.90	7.14	9.99
St Dev	1.77	0.53	6.91	1.37	4.93	8.86	6.01	2.89

Most participants spent more time in the document creation environment than they did in the research environment (See Table 13). The only participant to definitively spend more time in the research environment is A33. Participants A24 and A44 spent significant amounts of time in some form of split screen mode, which would make any definitive measurement of their document and research environment time unreliable.

Table 13 – Time Spent in Task Environment (in seconds)

	Total Time				Time per Minute		
Participant	**Total time**	**Document**	**Research**	**Split**	**Document**	**Research**	**Split**
A2	3606.7	2085.5	1521.2	0.0	34.69	25.31	0.00
A12	2866.2	2063.0	802.9	0.0	43.19	16.81	0.00
A13	3610.1	2250.7	1357.8	0.0	37.41	22.57	0.00
A14	3605.7	3015.4	590.0	0.0	50.18	9.82	0.00
A18	3603.7	2112.2	1491.2	0.0	35.17	24.83	0.00
A23	3602.8	2199.0	1403.4	0.0	36.62	23.37	0.00
A24	3769.7	26.2	1472.0	2270.5	0.42	23.43	36.14
A26	2453.8	2092.4	361.4	0.0	51.16	8.84	0.00
A33	3154.1	1492.9	1660.9	0.0	28.40	31.60	0.00
A44	2961.0	886.0	320.5	1752.4	17.95	6.49	35.51
A48	3352.9	2277.3	962.2	113.0	40.75	17.22	2.02
Total/Average	36586.9	20500.8	11943.4	4136.0	33.62	19.59	6.78

Point-based results

Internet actions were the most common actions utilized by the participant. This could be because the participants collectively spent approximately one third of their time in the research environment in which Internet actions are most likely to occur. Clicking and moving actions were very similar in volume, comprising the second and third most common actions (see Table 14). Moving actions also exhibited very large differences in volume between participants. For example, participant A24 only completed four moving actions while participant A23 completed 206 moving actions (see Table 15). Query actions were relatively rare in comparison to most other actions, but this result is not surprising because participants would not be expected to query throughout the entire session.

Table 14 – Actions per Minute

Participant	Clicking Options	Entering parameters	Inserting	Internet	Moving	Navigating Menu	Query	Total
A2	0.83	0.38	0.72	2.05	1.03	0.90	0.15	6.06
A12	1.30	0.02	0.44	1.00	0.73	1.44	0.06	5.00
A13	1.43	0.03	0.86	0.88	1.51	1.40	0.05	6.17
A14	0.80	0.03	0.27	0.40	0.52	1.16	0.18	3.36
A18	1.83	0.02	0.88	1.15	2.23	1.60	0.02	7.73
A23	1.47	0.30	0.82	3.20	3.43	0.85	0.20	10.26
A33	1.22	0.04	1.56	2.70	0.53	0.42	0.02	6.49
A26	1.81	0.68	0.12	2.10	1.74	1.42	0.05	7.92
A24	0.67	0.05	0.59	2.98	0.06	0.51	0.06	4.92
A44	0.85	0.16	0.81	2.01	3.14	0.99	0.18	8.15
A48	3.70	0.00	1.38	1.84	1.16	2.77	0.07	10.93
Average	1.45	0.16	0.77	1.85	1.46	1.22	0.10	7.00
St Dev	0.85	0.22	0.43	0.90	1.09	0.64	0.07	2.28

Table 15 – Total Actions

Participant	Clicking Options	Entering parameters	Inserting	Internet	Moving	Navigating Menu	Query	Total
A2	50	23	43	123	62	54	9	364
A12	62	1	21	48	35	69	3	239
A13	86	2	52	53	91	84	3	371
A14	48	2	16	24	31	70	11	202
A18	110	1	53	69	134	96	1	464
A23	88	18	49	192	206	51	12	616
A33	64	2	82	142	28	22	1	341
A26	74	28	5	86	71	58	2	324
A24	42	3	37	187	4	32	4	309
A44	42	8	40	99	155	49	9	402
A48	207	0	77	103	65	155	4	611
Total	873	88	475	1126	882	740	59	4243

Post-Task Questionnaire Results

Every participant that completed their live session also completed their post-task questionnaire. Likert scale responses were coded from 1 to 5 where 1 is Strongly Disagree and 5 is Strongly Agree (see Table 16). It should be noted that while the task instructions and the post-task questionnaire refer to Microsoft Word (see Q3 and Q5), three participants (A23, A26, and A44) opted to use another software application to create their brochure. In these cases, participants A26 and A44 reinterpreted the question to suit their choice of application. Participant A23 simply indicated that he did not use Microsoft Word.

Table 16 – Post-Task Questionnaire Responses

Participant	**Q1** My brochure is a useful resource for information.	**Q2** My brochure looks professional.	**Q3** I learned new skills in Microsoft Word.	**Q4** I experienced difficulty locating relevant information.	**Q5** I experienced difficulty applying information I found online to my Word document.	**Q6** I was given enough time to complete the research task.
A2	4	3	1	1	3	2
A12	3	2	2	1	1	5
A18	4	3	2	2	4	2
A13	4	2	2	2	5	5
A23	1	1	1	5	3	2
A14	2	1	3	3	5	4
A33	5	2	1	1	4	4
A26	4	3	5	1	2	3
A24	4	1	1	4	4	2
A48	4	4	4	2	1	4
A44	5	4	3	2	2	5

Most participants answered that they found their brochures to be a useful source of information. Conversely, six out of eleven participants did not think their brochure looked professional. This might suggest that while the information gathering process was not difficult within the allotted time frame, the presentation aspect of the brochure may require more time.

Participants A26 and A48 reported skill development in Q3. Participant A44 reported a neutral response, but he elaborated that he may have developed some skills in Microsoft Publisher. Participant A14 also reported a neutral response, but she elaborated that she was curious to return to her brochure and investigate the cause of barriers that she experienced during the task. These participants will become the subject of some discussion.

Activity Measurement and Post Task Questionnaire Correlation Analysis

A correlation analysis was run between each measured per minute activity category and each post-task questionnaire item. The results were largely inconclusive. However, each significant result has been listed below (see Tables 17 and 18). Out of 126 correlations measured (21 activity measurements for each post-task questionnaire item), only 5 significant results were found. This may mean that any conclusions drawn from these results should be treated with some skepticism and would require further research. However, 3 of the 5 significant correlations were found between question 3 (I learned new skills in Microsoft Word) and a measured activity or environment. Participants that reported skill development appeared to spend less time reading or exploring for information ($r_{(9)} = -.74$, $p < .02$) and less time in the research environment ($r_{(9)} = -0.78$, $p < 0.01$). It is important to keep in mind that time spent in the research environment overall is likely skewed because two participants spent a lot of time in a split screen environment. Conversely, participants that reported skill development also appeared to spend more time navigating menus ($r_{(9)} = 0.65$, $p < 0.05$). This may mean that participants that spent more time exploring options during the creation of their brochure were more likely to develop a new skill in the application that they were using.

Finally, participants that were satisfied with the amount of time (as reported in question 6) given during the task seemed to be negatively correlated with time spent evaluating ($r_{(9)} = -0.83$, $p < 0.01$). Question 6 showed examples of multiple interpretations with some participants indicating that they were given enough time while also elaborating that they were not able to complete the task. As a result, this finding would require additional research because it was the only activity (out of 21) that was correlated with this particular post-task questionnaire item, and the true nature of the item's responses are somewhat unreliable.

Table 17 – Q3 Significant Behavioural Correlations

Questionnaire Item	**Behaviours**		
	Reading per minute	Research Environment per minute	Navigating Menus per minute
Q3	-0.74, p = 0.01	-0.78, p = 0.005	0.65, p = 0.03

Table 18 – Q5 and Q6 Significant Behavioural Correlations

Questionnaire Item	**Behaviours**	
	Evaluating per minute	Vocalizations of Uncertainty per minute
Q5	-	0.66, p = 0.03
Q6	-0.83, p = 0.001	-

The coded live session data was also aggregated into research, creation, and no action categories for state-based activity. Similarly, the point-based actions were aggregated into research and creation actions. See Table 19 for activity groupings. These behaviours were grouped together based on their similarities and most likely use cases. These categories are meant to describe how various activities are used, and they do not exactly match the research and document creation environment data. This is because some behaviours occurred in either environment. For example, "Defining problem" could (and did) occur in either environment, but the purpose was more often than not to identify information needs, thus it was labeled a research activity.

Table 19 – Aggregated Live Session Behaviours

State-based Activity			**Point-Based Actions**	
Research	**Creation**	**No action**	**Research**	**Creation**
Defining problem	Typing information	Paused	Inserting, copying, pasting or saving information	Navigating menu and option screens
Defining query	Visualizing information	Blank	Internet actions	Entering parameters for built-in software functions
Exploring or reading information			Query actions	Clicking software options/using sliders
Evaluating information				Moving/repositioning/resizing/deleting objects

The aggregated scores were then correlated with the post-task questionnaire results (see Table 20). There were two significant positive correlations were found between the state-based creation activities and Q2 (professionalism) ($r_{(9)} = .68$, $p < .05$) and Q3 (skill development) ($r_{(9)} = .60$, $p = .05$). A significant negative correlation was found between state-based creation activities and Q5 (difficulty applying information) ($r_{(9)} = -.74$, $p < .02$). This suggests that participants who spent more time conducting state-based creation activities (typing and visualizing) may have found their brochures to be more professional looking and may have been more likely to develop technological skills. Additionally, they may have experienced less difficulty applying information they found online into their brochures. Finally, a significant negative correlation was found between state-based research activities and Q3 ($r_{(9)} = -.74$, $p < .02$). This finding is similar to the previous finding in that participants who spent less time engaging in state-based research activities may have been more likely to report technological skill development.

Table 20 – Aggregated Live Session Behaviour Correlations

Questionnaire Items	**Behaviours**	
	State-based Research	State-based Creation
Q2		0.68, p = 0.02
Q3	-0.74, p = 0.01	0.60, p = 0.05
Q5		-0.74, p = 0.01

There is a large disparity between the breadth of the coded live session data and the post-task questionnaire data. 21 data points were coded into data from the live sessions compared to 6 data points from the post-task questionnaire. Additionally, several post-task questionnaire items were open to interpretation in terms of the types of the competencies they may be referring to. For example, Q5 (I experienced difficulty applying information I found online to my Word document) could be interpreted to be either content information found from the Ripley's Aquarium or it could be technological information for applying document creation concepts into the brochure. Future studies may benefit from coding questionnaire responses to technological or information competencies as done in previous studies on digital competency profiling (Blayone, 2017). Doing so could potentially remove some ambiguity from the questionnaire responses and provide for more avenues analysis to examine where and when various forms of skill development may occur.

As noted above, few significant correlations were found between the post-task questionnaire items and the task activity. In particular, no significant correlations could be found between the task activity and Q1 (my brochure is a useful resource for information), Q2 (my brochure looks professional), and Q4 (I experienced difficulty locating relevant information).

Q3 (I learned new skills in Microsoft Word) was the only post-task questionnaire item to show multiple significant correlations to the measured task activities. Two significant negative correlations between this questionnaire item and time spent reading and time spent in the research environment. The nature of these significant correlations suggests that activity in the document creation environment (i.e., not in the research environment) can be helpful for developing technological skills. If this is true, it would also not be surprising because it would mean that engaging with the creation software helps develop skills in the software.

R2 – What behavioural profiles can be established that may help increase technological skill development?

Behavioural profiles were established by examining the types of activity that seemed to lead to positive responses to Q3 (I learned new skills in Microsoft Word) in the post-task questionnaire. State- and point-based measurements were normalized to help facilitate comparison across activity categories. The environment data was not normalized, and its dispersion was not measured due to the existence of the split screen environment, which could skew the results. The normalized data was then separated into quartiles to measure the dispersion of each activity. Finally, visualizations of each session were created to provide a general overview of the participant activity and work patterns (see Appendix B). The combination of this data was used to establish the behavioural traits of participants who did seem to develop technological skills.

Only two participants reported the development of new skills in Microsoft Word, participants A26 and A48. Participant A44 entered a neutral response in the same question, but wrote in his elaboration on his response, "some experience in Microsoft Publisher." This blurb, while brief, could be interpreted as though some level of skill development did occur despite the neutral response. However, six of the eleven (54.5%)

participants elaborated that they relied on skills they already had to complete the brochure. Participant A14 indicated that she did not learn new skills in Microsoft Word, but she did elaborate to say that the experience caused her to become "curious to figure out some of the areas I was getting stuck on." As a result, this section will put some emphasis on the activities of these four (A14, A26, A44, A48) participants.

Live Session Activity Normalization and Dispersion

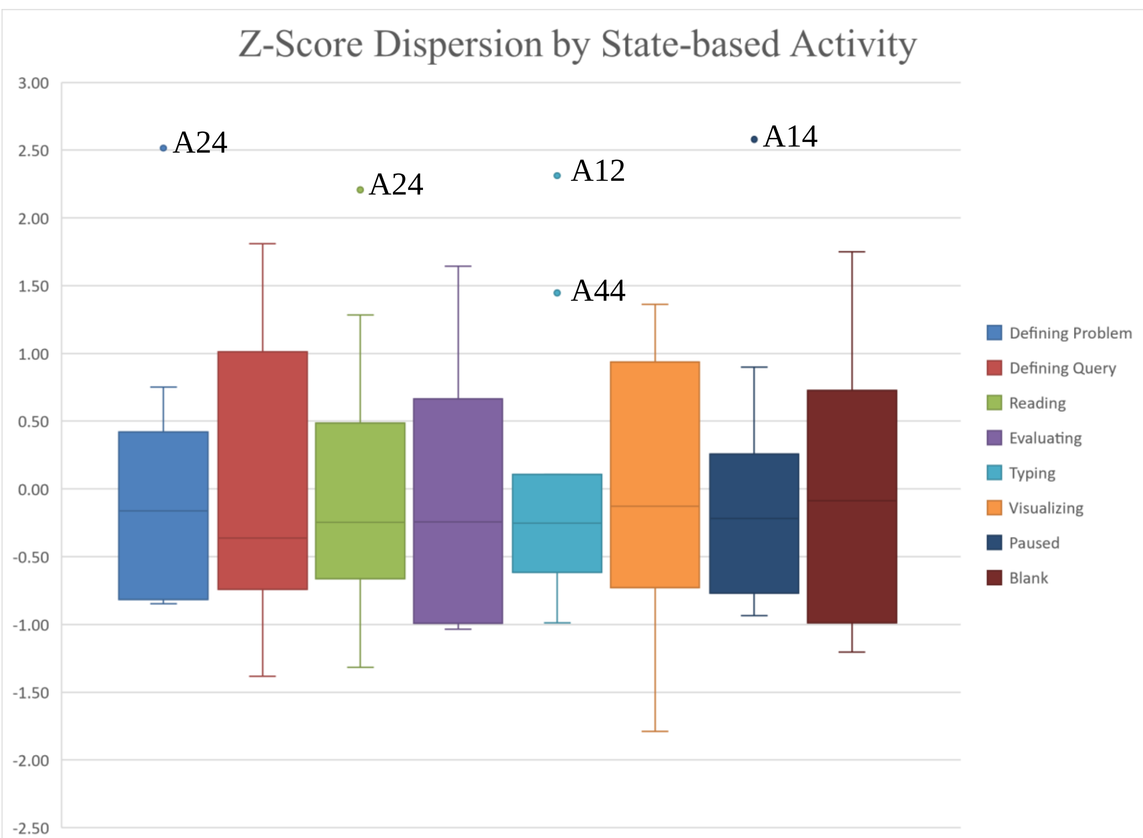
Defining query, evaluating, visualizing, and blank time displayed the most dispersion among the state-based activities (see Table 21). Defining problem, reading, typing, and pausing displayed much less variance in their Interquartile Range (IQR) when accounting for the existence of statistical outliers (see Figure 2). This is to say that the participants' activity levels within the former group were fairly consistent with the exception of one or two participants.

Table 21 – Z-Scores by State-based Activity

Participant	Defining Problem	Defining Query	Reading	Evaluating	Typing	Visualizing	Paused	Blank
A2	0.42	0.29	0.48	0.62	0.11	-0.16	-0.12	-1.20
A12	-0.83	-0.57	-0.83	-1.03	2.31	-0.67	0.26	0.67
A13	-0.46	-0.49	-0.24	-1.01	-0.77	-0.13	0.90	1.26
A14	-0.85	1.01	-0.25	-0.74	-0.12	-0.91	2.58	-1.08
A18	0.75	-0.74	-0.33	1.52	-0.99	0.94	-0.22	-0.99
A23	0.08	1.81	0.04	1.65	-0.25	0.65	-0.93	-0.86
A24	2.52	-0.36	2.21	0.67	-0.62	-1.79	-0.24	-0.04
A26	0.12	-1.00	-1.32	-0.24	-0.13	1.34	-0.18	-0.14
A33	-0.16	-1.38	1.28	0.22	-0.41	-0.73	-0.79	1.75
A44	-0.82	1.19	-0.38	-0.99	1.45	0.10	-0.49	-0.09
A48	-0.78	0.24	-0.66	-0.65	-0.58	1.36	-0.77	0.73
1st Quartile	-0.82	-0.74	-0.66	-0.99	-0.62	-0.73	-0.77	-0.99
3rd Quartile	0.34	0.83	0.37	0.65	0.05	0.86	0.16	0.71
IQR	1.16	1.57	1.03	1.65	0.66	1.59	0.93	1.70

It is important to not discount outlying data due to the small sample size and personalized nature of each participant's activity because all it took for a participant to become an outlier was to use an unconventional task strategy during their task. For example, participants A12 and A44 both show up as outliers in their typing activity (see Figure 2). However, this is because they were the only participants to type anything more than a few sentences at all, which would suggest that their activity should not be discarded for being abnormal. Participant A24 appears as an outlier in both defining problem and reading. This is consistent with his observed behaviour, in which he seemed to experience difficulty deciding on the information he wanted to use. His outlying behaviour in those two categories corresponded with the lowest amount of time spent visualizing. Finally, participant A14 experienced significant difficulty making modifications to the Word brochure template, which explains why her pausing activity was out of line with the rest of the group.

Figure 2 – Z-Score Dispersion by State-based Activity

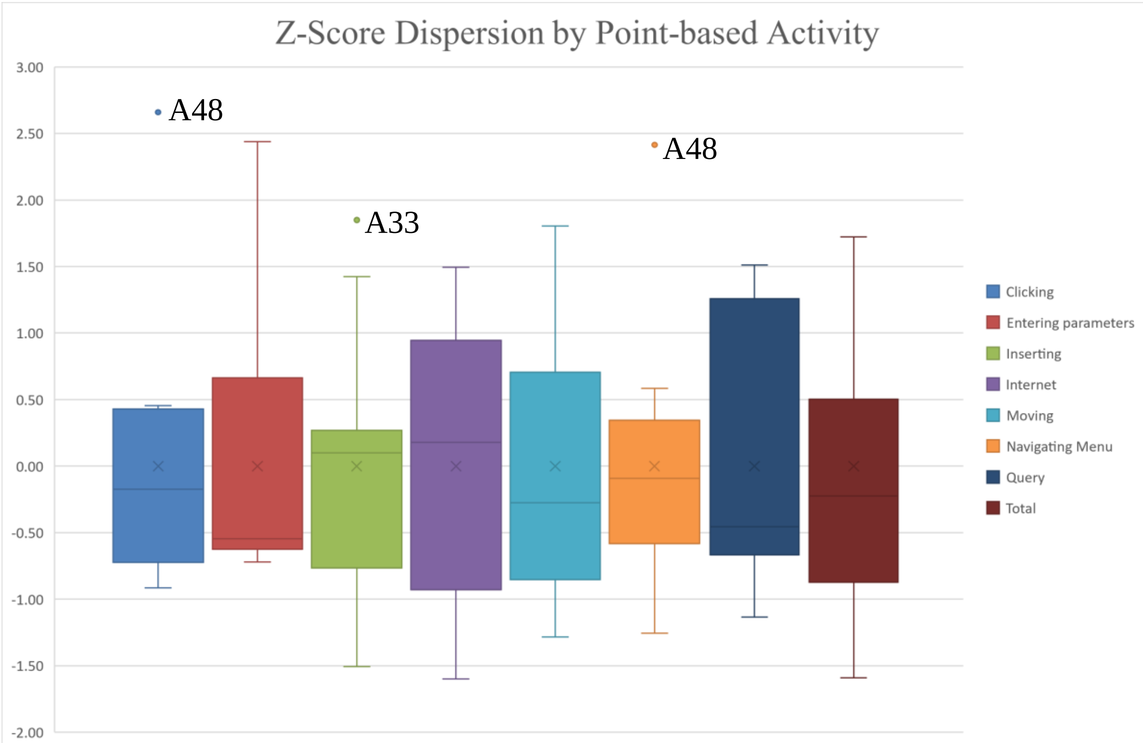


For point-based actions, Internet and query actions displayed the most dispersion as represented by their Interquartile Range (IQR) scores followed by moving actions (see Table 22). This could be partly explained by the fact that both actions typically occurred within the research environment while other actions do not. Conversely, clicking options and navigating menu actions did not show much dispersion, which like the previous pair of actions can be partly explained by the fact that these actions would occur mostly within the document creation environment. Participant A48 was an outlier in both clicking options and navigating menu options (see Figure 3). It makes sense for this pair of outliers to be the same participant because a clicking action can often come as the result of a navigating menu action.

Table 22 – Z-Scores by Point-based Activity

Participant	**Clicking Options**	**Entering parameters**	**Inserting**	**Internet**	**Moving**	**Navigating Menu**	**Query**	**Total**
A2	-0.72	1.04	-0.12	0.22	-0.40	-0.51	0.79	-0.41
A12	-0.17	-0.62	-0.77	-0.93	-0.67	0.34	-0.47	-0.87
A13	-0.02	-0.57	0.23	-1.07	0.05	0.27	-0.65	-0.36
A14	-0.76	-0.57	-1.17	-1.60	-0.87	-0.09	1.27	-1.59
A18	0.45	-0.64	0.27	-0.77	0.70	0.58	-1.13	0.32
A23	0.02	0.66	0.11	1.49	1.81	-0.58	1.51	1.43
A33	-0.27	-0.55	1.85	0.95	-0.85	-1.25	-1.10	-0.22
A26	0.43	2.44	-1.51	0.28	0.25	0.30	-0.67	0.40
A24	-0.92	-0.50	-0.42	1.25	-1.28	-1.11	-0.46	-0.91
A44	-0.70	0.03	0.10	0.18	1.54	-0.36	1.26	0.50
A48	2.66	-0.72	1.42	0.00	-0.27	2.41	-0.34	1.72
1st Quartile	-0.72	-0.62	-0.77	-0.93	-0.85	-0.58	-0.67	-0.87
3rd Quartile	0.43	0.66	0.27	0.95	0.70	0.34	1.26	0.50
IQR	1.15	1.29	1.03	1.88	1.56	0.93	1.93	1.38

Figure 3 – Z-Score Dispersion by Point-based Activity



Live Session Activity Visualizations

Visualizations were created for each participant's session. Example visualizations can be found in Appendix B. See Figure 4 for an example of a visualization. Participant activity did not follow any clear patterns across all participants. Participants A14, A23, A26, and A33 all exhibited fairly clear dividing lines in their activity, which split their process into two phases. The first half is dedicated to finding, reading, and selecting information in the research environment, while the second half is for visualizing information in the document creation environment. In the case of participant A23, there is a very clear delineation of activity. The research environment is by far the most common environment for this participant until approximately the 25-minute mark. This environment is accompanied by lots of time spent reading and exploring, and to a lesser extent defining problems and evaluating. Most of the participant's activity during this time consists of Internet actions. After the 25-minute mark, the activity shifts to the document creation environment, along with lots of time spent visualizing information. This activity corresponds with a decrease in Internet actions and an increase in clicking options and moving objects actions. For participant A26, the delineation occurred early at around the 15-minute mark. For participant A33, it occurred very late at around the 42-minute mark. However, not all participant activity can be so easily delineated.

Figure 4 – Example of Timeline Activity Visualization

Some participants displayed short, repeating patterns for extended periods throughout the task. Participants A12, A13, A18, A44, A48 displayed this type of activity. Participant A18 showed similar patterns of researching and creating, but on smaller scales throughout the task. During his task, A18 routinely displayed small patterns of exploring or reading followed by either evaluating and visualizing or just visualizing. In practice, his patterns were characterized by periods of information searching followed by selecting, inserting, and visualizing. Once the participant felt he had selected and pasted enough information, he would spend time fitting it together before going back to find and select more information. Participant A48 displayed a very similar pattern, but her patterns occurred a much faster rate.

Participant A44 took more time to find his work pattern in the task, and his pattern took a slightly different form. While his activity in the first half of the session did not present any clear patterns, the second half was characterized by periods of typing, followed by a short period of reading or exploring and then visualizing. In practice, this took the form of typing out information directly from the website and then inserting and adjusting images.

The remaining participants (A2, A24) exhibited activity that displayed less discernible patterns across their entire task. Participant A2's visualization shows a more vague split between the first and second half, similar to participant A23. The difference is not as stark due to the periods of typing and visualizing that occurs between the 8-minute and 17-minute marks. However, patterns of reading or exploring followed by visualizing still occurred in variable lengths throughout the task, but they did not occur for extended periods of time throughout the task. Both A2 and A24 displayed an extensive period of nearly uninterrupted reading or exploring.

Participants A26 (who reported skill development) and A14 (who expressed interest in investigating the barriers she encountered) both fell into the first group with clear first and half second half splits. Participants A48 (who reported skill development) and A44 (who did not report skill development in his survey but did in his elaboration) both fell into the group of small, repeating patterns. No participants from the third group reported skill development.

Implications of Activity Behaviour

It is difficult to make any recommendations on specific behavioural profiles that lead to self-reported skill development. However, there were some interesting results in the two participants (A26 and A48) that reported skill development in their post task questionnaire. These participants were the most frequent visualizers during the study based on their Z-scores. Participant A48 ranked first at 1.36 SD, and participant A26 ranked second at 1.34 SD. Participant A48 ranked first in menu navigation actions at 2.41 SD and first clicking actions at 2.66 SD. Participant A26 ranked first in entering parameter actions at 2.44 SD. If participant A44 is included in this analysis due to his elaborated acknowledgement of skill development, all three participants were above the mean in time spent visualizing and total actions. They were below the mean in time spent reading, evaluating, and pausing. All three were very near the mean in Internet actions.

This analysis implies that participants who spend more time creating and less time exploring information on the Internet may have been more likely to develop technological skills. These participants displayed fairly consistent activity levels throughout their task without extended pauses. In other words, participants who spent more time engaging with their technological learning object may have been more likely to develop technological skills. This would be consistent with constructionist pedagogy, which emphasizes learning by doing (Papert, 1993). However, these findings are tentative and require more research.

R3 – How can engagement in a construction-based online research task provide evidence for technical or informational skill development?

While two participants reported skill development, as seen in the post-task questionnaire results, there was little evidence that widespread skill development occurred during this study. The two participants that did report skill development also displayed high levels of engagement in the document creation application. However, some factors related to information searching behaviour and task design may have affected how the remaining participants approached the task from a technological skill development perspective.

Using a Search Engine to Solve Problems

One of the initial goals of this research project was to determine the effectiveness of using the Internet as a learning tool in technologically rich creation tasks. However, the results of the participant activity showed very little evidence of participants using the Internet as a technological learning tool at all. In general, query action activity was much lower than the other types of coded activities with participants ranging from one to 12 query actions in a single session compared to other actions which tended to be in the double or triple digits. Most of these queries involved searching for either images or a brochure creation application. Only two participants (A14 and A48) used the Internet to address a technical issue.

This may be partly explained by the fact that few participants reported difficulty locating information. Eight of eleven (72.7%) participants reported no difficulties locating relevant data. Four of those participants explicitly referred to the fact that the website for Ripley's Aquarium was provided to them as a reason they did not experience difficulty. For example, participant A26 wrote, “I was provided with a website which made everything easy to find and locate.” This is not to say that the presence of the website link in the task instructions definitively made the task easier for all participants. Participant A24 wrote, “I find it hard to get the top attraction or activity in the website that I can place in the title page.” This might suggest that participant A24 was looking for information about the popularity of attractions at the aquarium, which couldn’t be determined from the website alone.

Participant A14 experienced many issues formatting her brochure that she created from a Word template, but she was persistent in her attempt to complete the brochure. Her 3.36 actions per minute were the fewest of all participants, and she made multiple vocalizations that indicated a lack of confidence in her own ability (“Since I’m not the best at this, I may have to go back and forth a bit”), which may indicate low technological skills. Her 22.64 seconds per minutes spent paused was also a statistical outlier at 2.58 standard deviations above the mean. However, despite repeated pauses in task activity and vocalizations of uncertainty—both of which were the most among all participants—she began to use Google in an attempt to remove an extra page from her brochure late in the session near the 58-minute mark. Since this transition in problem solving method occurred so late in the session, she was not able to resolve the issue within the remaining two minutes. It remains unknown then if she would have been able to resolve the problem, and thus potentially develop a technological skill had she not been cut off due to the expiration of the timer.

Participant A48 also used Word to create her brochure, but she did not use a template. She paused during the task the third least among all participants. Her 2.77

navigating menu and 3.70 clicking actions per minute were both statistical outliers at 2.41 and 2.66 standard deviations above the mean, respectively. Finally, in her post-task questionnaire she expressed confidence in her own Word abilities ("I'm a proficient Word user …"). The combination of these factors may indicate strong technological skills. Around the 27-minute mark, she used Google to see if it was possible to change the background colour of a Word document. After about two minutes of Googling and reading, she was able to resolve her issue to her satisfaction.

The fact that these two participants exist on opposite ends of the measured spectrum in this study is interesting. Both participants exhibited behaviour that could be described as extreme within the bounds of the study and may represent two ways in which information searching behaviour can be initiated. In the case of participant A14, her usage of Google seemed to be the result of frustration with her state of progress. In the case of participant A48, her usage of Google seemed to come naturally once she identified a gap in her knowledge and a point of progress she wanted to achieve in her brochure.

Counter examples for participants A14 and A48 behavioural profiles can also be found. For example, participant A14 was not the only participant to experience frustration and pauses. Participant A13 ranked second in both vocalizations of uncertainty and time spent paused, and yet she did not resort to Google to resolve technological issues. Participant A48 was not the only participant with outlier point-based activity. For example, participant A33's 1.56 inserting actions per minute was a statistical outlier at 1.85 standard deviations above the mean. Participants A23 and A44 were not statistical outliers, but their moving actions were 1.81 and 1.54 standard deviations above the mean, respectively. It is not recommended that A14 and A48's outlier behaviour be interpreted as proof of circumstances required to prompt technological problem querying.

As such it may be more useful to examine why the other participants did not use Google to resolve technological issues. In some instances, it may be that the participant did not encounter any issues that they saw the need to resolve. In other instances, the answer may lie in the existence of the timer and the need to create something within the time limit.

In notes taken during the video coding process, this behaviour was identified under the term "path of least resistance." This type of behaviour often took the form of avoiding barriers that the participant was unsure of how to resolve or that would take too long to resolve. For example, when trying to resolve an issue involving object grouping, participant A2 abandoned his current set of actions for another, saying, "This is tricky. You know what, that's fine. I'm just going to create another text box." In his post-task questionnaire, he remarked that "The skills that I utilized mostly came from my previous experience." This may indicate that the participant attitude towards creating his brochure was centered around creating something useful with the skills he already has.

Participant A44 exhibited a very similar behaviour when attempting to paste information directly from the Ripley's Aquarium website. The pasted information appeared in his brochure in multiple text boxes, which he experienced difficulty rearranging to his satisfaction. Once his dissatisfaction reached its limit, his solution was instead to type the information directly to his brochure. Participant A44 was concerned that more copying and pasting would cause formatting issues in his brochure so he opted to type it directly himself. When making the decision to adopt this method, he said of copy and pasting that "… formatting might be weird. So, you know what, I'm a fast enough writer." In this sense, his actions appear to be a time saving mechanism to rely on skills he feels he has to avoid unnecessary complications. This is to say, that if the goal of the task is to create a brochure in 60 minutes, it may not be an effective use of time to determine the existence or cause of a problem, research, and then apply a solution when a different approach based on known skills may be faster.

This behaviour is also consistent with findings from Kirschner & van Merriënboer (2013) which states that learners tend to avoid developing new digital skills in favour of using skills they already know. Another factor to consider is the effect of the task design in the study outcome regarding its usage of the "uncertainty principle." Kuhlthau (2004) theorized that the uncertainty principle acts as an impetus in seeking new knowledge. If a participant did not find themselves in a situation where their current skills and desired outcome do not align, they may not experience an impetus to seek new knowledge (van Oostveen et al., 2018). In other words, there may be no internal motivation to address that knowledge gap. If introducing a gap in knowledge is a desired outcome of the task, then task design is an important consideration for future studies.

Structuring an Exploratory Task

When asked if they experienced difficulty locating any information that they intended to find (see Q4 in Appendix A2), most participants (8/11) reported that they did not. When asked to explain the reasoning behind their responses, four participants expressed in some form that they did not experience difficulty due to the resources provided to them in the task instructions. For example, participant A33 wrote that having the two brochures provided in the task instructions helped to know what to look for on the website, which was also provided. Participant A26 wrote that he did not face difficulty because having the website helped to locate relevant and important information. Participant A18 wrote that most of the information was on the provided website so it was not difficult to locate information.

This raises an issue with task design for exploratory tasks and the factors that influence exploratory searching. Despite the presentation of the task as an information problem, the goal of the task was to develop technological skills. The researcher is then presented with a choice as to how they can present the problem to the participants. The researcher could choose to provide no supporting documentation, which could require the participant to do more information seeking before engaging with the creation portion of the task. It could remove biases stemming from the researcher's presupposed ideas of what an example brochure looks for. Such a problem may be more complex due to the removal of task structure, creating additional uncertainty and outcome possibilities (Campbell, 1988). If the participants have to look up a brochure example themselves, they may come across more varied examples. They may be required to make their own decisions as to what a brochure looks like and what kind of information goes on it, which promotes engagement in the act of defining the problem (Young, 1993). However, in a timed task such as this one, they may also have less time to engage with the document creation environment as they might be required to perform extra research to decide their task goal and information sources.

The other option would be to provide information resources in the task description. This may allow the participant more time to engage with the document creation portion of the brochure since some of the information seeking work is already done for them. By having more time to create, participants might have more time to explore software options and problem solve. However, providing resources could introduce researcher biases of what brochures look like, as mentioned before. Participants might not be required to make as many decisions regarding information sources and their quality. If the information sources have been provided, their usefulness might be implied to the participant since they were chosen by the researcher.

In this study, the second option was chosen. However, the evidence indicates that pre-provided resources did not seem to encourage participants to problem solve technological barriers. Instead, participant behaviour could largely be described as a process of finding information from the provided website and putting it somewhere in the brochure. Participants A18 and A33 best exemplify this behavioural profile because much of their information gathering activity involved searching the website for information, screen-capturing it, and then pasting that screen-capture into their brochure. Participants A13 and A48 also used screen-capturing, though less extensively. Participant A44 did not use screen-capturing, but his behavioural profile settled on a pattern of copying and inserting an image followed by typing text directly from the website.

Learning problems can be divided into three categories: given, goal, and own (Watts, 1991). Each problem type contains different degrees of abstraction. Watts described the problem types as follows:

> …it is useful to distinguish between GIVEN problems, where the solver is given both the goal and strategies; GOAL problems, where the solver is given the goal and nothing else- the solvers have to decide and develop their own strategies; and

OWN problems, where solvers decide both the goal and the strategies (Watts, 1991, p. 8).

What was presented to the participants could be an example of a goal problem, where the learner is presented with a goal and must develop their own strategies to reach it. However, due to the existence of sample brochures in the study task, participants may not have been required to develop their own strategies, thus potentially making it resemble a given problem. This was not an intended effect of providing the example brochures. However, the evidence for this can be seen in the previous comments by participants A33, A26, and A18 and the finding and selecting behaviour exhibited by participants described above. By relying on the provided website and brochure, individualized problem definitions and solutions may not have been required, making the study task more closely resemble a given problem.

Another way to examine the effect of the provided brochures is to compare them to the participant's products, though it should be noted that the quality of the participant brochures is not being assessed in this analysis. The first brochure example was a booklet, structured similarly to a magazine. The second brochure example was a tri-fold pamphlet. These examples were provided to show what a brochure might look like. However, almost all participants seemingly opted to copy one of the provided brochure styles. Participants A2, A12, A18, A14, A33, and A48 created full page booklet brochures that resembled the first example. Participants A13, A23, A24, and A44 created tri-fold brochures that resembled the second example. Put another way, by including brochure examples, the task problem may not have been ill-defined (Campbell, 1988; Herrington et al., 2006).

Interestingly, participant A26, who was one of two participants to report skill development, was the only participant whose brochure did not fit into the archetypes of the provided brochures. His brochure looked more like a single page card. “I had this idea of using a single page template sort of brochure with important information,” he said of his brochure after being prompted to continue speaking late in his task. In this case, the important information he referred to included basic contact information and a short list of programs that Ripley’s Aquarium offered at the time. This was a significant deviation from the provided examples and possibly the closest demonstration of a goal problem.

Beyond the existence of pre-provided information, there are other factors that make this task design incomplete from a constructionist perspective. One important factor is the reflection period. Participants were given opportunities to rate and reflect on their brochures, but there was no opportunity within the study to measure the value or effect of the reflection. For example, in true constructionist design, learners are given the opportunity to share their work with a group of peers (Papert, 1993; Laurillard et al., 2013). This allows the learner to conceptualize and define what they have learned. However, no social component was incorporated into this task design because it was outside the scope of practicality. It is a much larger task from a research perspective to organize sharing sessions in addition to the live session and a post-task questionnaire. Despite this limitation to the study design, it may still be worth adding a social dimension to a similar type of study since there is evidence that peer-assessment can help develop computer skills (Hsu, 2016). Additionally, communities of practice may also help foster engagement in computer skills classes (Al Hashlamoun & Daouk, 2020).

However, it is possible that a simple design revision could assist the participants in skill development or problem definition awareness. Some participants identified areas of improvement or things they would have done had they been given more time. Participant A33 said that she would have properly inserted hyperlinks. Participant A14 identified a new strategy that she could incorporate by saying “I could have figured out how I wanted the brochure to look and then should have started editing.” Participant A2 said that he would have liked to “polish the graphics and wordings.” A possible method to allow participants to put their reflection into practice would be to conduct a two-phase live session separated by a reflection period.

There could be a couple benefits of such a design. Firstly, participants would be given the option to reflect on and assess their work and apply the results of that process into their work. Secondly, it could provide benefits from a research perspective by producing two data sets of coded activity (i.e., before reflection intervention and after reflection intervention) for the purposes of comparison. As such, any results provided in a post-task questionnaire by the participants could be investigated as the product of the reflection period.

There is also potential tension between this discussion and the findings for research question R1. Studies on digital skill measurement or Internet problem solving tend to use timed tasks for their participants to complete. This makes sense from a researcher perspective because it sets reasonable limits on the workload for researchers. However, it also means if a participant uses the full provided time in a task where two or more environments are measured, that participant will be splitting time between these environments. In other words, the more time a participant spends in one environment, the less they will spend in the other. Thus, the tension is that the findings for R1 suggests more time in the document creation environment may be useful for developing technological skills, but if the goal is to create goal or own problems (Watts, 1991), more time may need to be spent in the research environment to define the problem and develop solutions.

This tension suggests two things. Firstly, using a timed task may not be ideal for this type of study. A timed task may assume that all participants require the same amount of time to make significant progress in the task. However, this may not be true (see Concerns About Time and the Presence of a Timer). In this study some participants like A26 were satisfied with their work in less than the task time. Others, like A24, used most of their time to orient themselves in the task without making what would appear to be significant progress. The amount of time that any participant who did not complete the task would have taken is currently unknown. Additionally, if there are no time limits on the task, there would also be less tension from one environment taking time from another.

Secondly, assuming that goal or own problems are a desirable part of the task design and that such problems would require more time spent in the research environment, it may be worth examining more closely the types of activity that can occur within the research environment and which activities are more conducive for technological skill development. This is to say that despite evidence to suggest that less time in the research environment may be beneficial for technological skill development, this evidence may be better explained by ways in which the environment is utilized. For example, if technological skill development is negatively correlated with time spent reading or exploring, additional time could be allocated into evaluating and defining queries. It may also be worth investigating the types of information that is being read (e.g., is it content information or instructional information?) or the variety of resources visited.

Finally, a study that generates data over multiple periods of time might be a better option for a study like this because the research and creation processes in real life typically don't occur within time frames as short as 60 minutes. Often, research occurs in iterations of information gathering, creating, and reflecting over longer time periods (Kuhlthau, 2004). Participant A14 wrote in her post-task questionnaire that "I am generally a person who never does things in one sitting. I often start my version of a rough draft, save it, and then come back to it, and then edit it.". This style of work is more consistent with Kuhlthau's ISP model, which was created via longitudinal studies. Additionally, studies carried out over a long time already represent a gap in the research (Hendahewa & Shah, 2015). A suggestion would be to collect data over the course of a project that could last anywhere from a few weeks to a year. Such a study may provide more examples of long-term decision making, reflection, and skills development.

Requests for Guidance and Direction

Several participants used the researcher as a source of guidance throughout the task. Wherever possible the researcher declined to answer questions related to the quality of brochures or recommendations for future actions. Some of the questions from participants related to the boundaries of the task. These questions typically focused on what the participants can do or are allowed to do to complete their brochure. Participant A2 asked if he should be concerned about copyrights early in his task. Participant A12 wanted to know how long the brochure should be. Participant A48 wanted to know if all the information in her brochure needed to be true. Participant A23 asked if he should be concerned about the time. Participant A26 wanted to know which browser he should use if he chose to use an online tool for creating his brochure. Participant A48 asked if he could use software that he already had.

Other questions involved using the researcher as a source of information or feedback. Early in his task, participant A12 showed a tendency to use the researcher as an information source. For example, around 8 minutes into his session, he asked the researcher if Ripley's Aquarium was a local or national attraction. Roughly 4 minutes later he asked the researcher if the researcher had ever been there before. When the researcher said that he had not, A12 said, "Okay, so I'm on my own then." Participant A26, in the last 10 minutes of his session, asked the researcher for an opinion on whether or not his brochure looked good.

Both types of questions may reflect certain attitudes towards the purpose and perception of the task. The former examples seem to relate to the task as an assessment in that the participants appeared to be seeking the bounds of the task. What applications are they allowed to use? What is the length? Is copyright a concern? These are questions that may be familiar to an educator, but they may not be the types of questions one might receive from someone taking ownership of their task.

The latter set of questions appear to be more concerned with the knowledge or opinions that the researchers has as a resource. In the case of participant A12, he could have used a search engine to help answer his questions. Instead, he opted to use the researcher as a resource. This may be explained by his proximity to the researcher (they are currently in a voice call together) and the knowledge the researcher has of the topic (he chose the topic). This may create the perception that the researcher is a more economical use of time and energy as a resource over the uncertainty of a search engine. This would also be consistent with the “path of least resistance” behaviour described earlier due to the ease of access to the researcher. If Internet searching is considered to be a skill that needs development, then this finding may also be consistent with evidence that learners tend to prefer utilizing known skills over skill development (Kirschner & van Merriënboer, 2013). Finally, this may also be explained by student perceptions of teachers as information authorities in traditional classroom environments (Brown et al., 1989).

R4 – What barriers to construction-based online research tasks can be identified? Can any identified barriers be mitigated?

Several potential barriers were identified that may have affected how participants approached the live session task. As discussed in the study framework, the study task was designed to potentially reduce barriers to engagement in a construction task. When asking if informational exploratory searching can reduce barriers for activity and promote the engagement of technological skills, this study appears to be promising on the surface. Once a participant started the task, they either worked for the full 60 minutes or finished the brochure to their satisfaction before the time limit expired. One participant withdrew early in the data collection period prior to beginning the task. Some areas of concern have been addressed below.

Concerns About Time and the Presence of a Timer

The time limit during the task seems to have had an effect on the participants, though the nature effect is not immediately apparent. Eight of eleven ($72.\overline{27}$%)

participants mentioned time or the timer in some fashion during their session. Five of eleven ($45.\overline{45}\%$) participants indicated that they could have used more time in the elaboration of their post-task survey. Four of those five participants indicated in their post-task questionnaire responses that they were not given enough time. Participant A33, who indicated that she was given enough time, also wrote in her elaboration response that if she was given more time, some tasks would have been completed properly, which might indicate she was cutting corners to produce an object within the time limit.

Additionally, indicating on their post-task questionnaire response that they were given enough time does not necessarily mean that they considered their brochure to be complete. For example, participant A13, who indicated that she was given enough time, also said that she did not complete the brochure. However, despite that, she also said that she was pleased with her progress. This seems to suggest she was interpreting this question in relation to her view of the amount of time she would need to complete the task normally.

Finally, participant A26 provided a neutral response to the post-task questionnaire item on time, indicating that it was enough for him, but that it may not be enough for someone else. This might suggest that he was aware of the time requirements in relation to his brochure (it was a single page pamphlet with basic information) and that someone creating a larger brochure would take more time.

Comments about time during the live session also took different forms so their meaning cannot be considered equal across participants. For example, participant A44 made two comments on time. Both of these comments expressed annoyance that a particular subtask was taking a long time. Despite these comments, participant A44 still completed the task in less than the allotted time. Participant A48 also made two comments on time, one of which also expressed that she was spending too much time on a particular subtask. The second comment was about changing her work methods to save time. Once again, participant A48 completed the task before the 60-minute timer expired.

Participant A13 made four comments about time, and the purpose of these comments varied more in meaning. Early in the task, A13 stated “Any time something is timed, I want to get it done within the time limit.” This statement may indicate that the presence of the timer may be encouraging her to value a finished product over the learning experience. This statement is interesting because it seems to conflict with her comments in her post-task questionnaire, where she seemed to expect to not finish within the time limit. A13 also made two comments that certain subtasks were taking too long or that she was losing time. A13 even purposefully neglected to complete some subtasks in an attempt to save time.

Multiple participants began making comments regarding time in the second half of the allotted time. Some of these comments expressed a theme that the participant needed to hurry up or complete the task before the timer ran out. For example, participant A23 made two comments on time. The first comment was at roughly the 38-minute mark, and it expressed that he should hurry up. The second comment, which was around the 46-minute mark, expressed that he was falling behind. Participant A2 wondered how much time was left at roughly the 46-minute. About 30 seconds later, he expressed that he wanted to wrap it up to complete the brochure.

The timer may represent a factor that discourages exploratory searching because in the context of a task, participants may have prioritized a complete (or functional) product over the opportunity to develop a technological skill. This can be evidenced through multiple responses from participants that expressed their reliance on previously developed skills as opposed to newly developed skills (see Using a Search Engine to Solve Problems). Though that could also be explained by evidence that people may avoid tasks where they could perform poorly (van Laar et al., 2019). As a result, the timer may have affected participant behaviour and as such may represent a barrier.

Exploratory Construction Tasks as an Assessment

Evaluation anxiety and task performance have been found to be negatively correlated to each other (Sotardi et al., 2020), which suggests that it could be beneficial for learning activities to not feel like assessments. It is difficult to determine the effect that evaluation anxiety may have had on the task. However, during the introduction to the task, it was explained to the participants that their performance in the task was not being graded by stating "I am not grading or judging your performance in the task or assessing what you produce." This is to say that the quality of the completed (or uncompleted) brochures were not assessed with any rubric by the researcher. The only criteria by which they were evaluated was the post-task questionnaire reflection by the participants themselves.

With that said, there is still evidence that the participants viewed the task as some form of assessment. For example, participant A44, after removing some text and replacing it with a logo, said, "I think the logo looks better. I'll let you be the decider of that, but I think it's fine." Participant A48 needed to be prompted to continue speaking after a couple minutes of silence, after which she remarked "it's like I'm doing an assignment."

Some participants were concerned about copyrights or plagiarism when finding and selecting information from the Internet. Early on in his task, participant A2 asked if he needed to be concerned about copyrights. Similarly, participant A12 commented within the first five minutes that he was thinking "if I'm going to have plagiarism at the moment for copying pictures on the Internet." Participant A18 commented that since the brochure wouldn't be distributed anywhere that he hoped there is no issue with copyright. It should be noted however that when interpreting the wording of the task, concern over copyright would be a valid concern for a "professional brochure" as stated in the instructions.

In all of these cases, there is no clear evidence that any conceptualization of the task as an assessment was a barrier to engagement in the task. Participant A48, despite comparing the task to an assignment, displayed 10.93 actions per minute during her task, which was the most in the group and spent the third least amount of time paused during the task at 2.52 seconds per minute. Participant A12, who was concerned about copyright, displayed the third fewest actions per minute at 5.00 and spent the third most time paused at 8.69 seconds per minute. However, he did not exhibit any significant pauses until over 20 minutes after his comment on plagiarism, which would suggest that they are not connected. Comments on assessments and plagiarism may have been a method to connect the task process to a structure that is more familiar to them.

Computer Self-Efficacy as a Barrier

One of the anticipated barriers in this study was low CSE, which had the potential to discourage participants from completing the task (Savoleinen, 2015). While the effects of CSE were not explicitly measured, its effect may not have been too detrimental to the study participants. No participants who began the task quit the task out of frustration or fear of failure. Every participant who completed the task early did so because they considered their brochure to be finished according to their own standards. Several participants (notably A13, A14, and A24) did experience difficulty creating their brochures for various reasons, yet all three of them persisted in the task until the time was up. However, one participant withdrew prior to beginning the brochure after expressing that she did not have the ability to complete the task. After her withdrawal, the researcher made extra effort to remind participants that their work would not be graded and that the purpose of the study was to examine how they approached the problem. No further withdrawals occurred after the researcher enacted that change.

Participant A12 also experienced difficulties as represented by his third highest pause rate (8.69 seconds per minute), and he completed his session early (approximately 48 minutes). However, he did not express dissatisfaction in his progress relative to his skills. In his post-task questionnaire, he considered his brochure to be neither useful nor professional, but when asked about the time limit, he wrote, “I think considering that this was my first time, I personally think I did a pretty good job with the skills and the techniques I know at the moment.” This evidence suggests that the negative effects of low CSE may have been mitigated.

Additional Emergent Themes

Two additional themes were identified that did not match the research questions, but they were worth discussing because they may have affected the manner in which participants engaged with the live session task. These themes were both related to the fact that the study was conducted during the COVID-19 pandemic.

Conducting Live Participant Tasks in a Remote Environment

It is a given that sociological inquiry experiences what can be referred to as observer effects, where the actions of the participant can change due to the knowledge that they are being observed. For instance, participants may consciously or unconsciously change their actions to present themselves in a more favourable light or censor themselves so that they do not reveal what they truly believe (Monahan & Fisher, 2010; LeCompte & Goetze, 1982). Monahan & Fisher (2010) also argued that though the presence of the observer can change the behaviour of the participant, it does not invalidate the findings especially when factoring that there was a researcher present. For example, if the participant is changing their behaviour to please or impress the researcher, then what they choose to show the researcher or how they choose to behave can reflect their values of acceptable behaviour.

Due to the COVID-19 pandemic, this study was conducted in a completely remote, online environment. No physical laboratory was used to plan, schedule, or conduct any data collection in this study. At the time of the publication of this thesis, the COVID-19 pandemic is still on-going, which may mean that there is a need for frameworks for conducting naturalistic inquiry and live interventions with participants that are specific to online environments. There are a number of factors that can differentiate fully online inquiry from in-person inquiry. The effect of these factors may not be immediately apparent in all cases, but they are worth acknowledging.

Firstly, while other studies on Internet research and digital problem solving referenced in this paper were often performed in a physical lab setting, the participants in this study performed their task at home or the location of their choosing. This leaves a wide variety of distractors outside of the control of the researcher. Some examples of distractors that did occur during this study include inconsistent Internet connection, low batteries (resulting in the need to find a charger), another person walking in on or speaking to the participant during the study, caring for children, and accidentally muted microphones. These distractors may have had an effect on the participant during the task by dividing their attention or even affecting their ability to speak loudly and clearly in a think-aloud task.

Secondly, the role of the researcher may change depending on their physical proximity to the participant. For example, in an in-person study the participant may be physically situated near the participant, either next to or behind the participant while they perform the study task. The researcher may also be writing notes while the participant is working. However, in a remote, online setting, the researcher may not be as visible to the participant. During this study task the participants were working in either Word or a document creation application of their choice. They were also using the Internet to find information for their brochures. This means that the Google Meet sessions, and thus the researcher, were not visible to the participant during the vast majority of the task time. Participant A26 briefly had the meeting window open to unmute his microphone. Participant A24 occasionally brought up the meeting window to ask a question. However, these situations were rare.

Participant A48, when prompted after an extended period of silence, remarked, “You know, I’ve almost forgotten that it’s a study, and I’m just doing what you told me to do.” When there was no immediate response, she asked, “Hello?” to ensure that the researcher was still there. This is not to suggest that the presence of the researcher can be removed entirely or even that observer effects are minimized during an online study. For example, multiple participants still sought the approval of the researcher regarding their brochure designs or insinuated that the researcher would be assessing their work despite being told that he would not. However, it remains possible that observer effects may potentially be altered from that of an in-person study. This effect could also be compounded when combined with the fact that the participant may be performing the study in an environment that is much more familiar and comfortable to them (i.e., their own home, their own computer) than a lab setting.

There is evidence that research conducted in a physical laboratory can be replicated in an online environment (Woods et al., 2015). Indeed, some findings in this study were consistent with findings produced by Brand-Gruwel et al. (2009) and Kirschner & van Merriënboer (2013). However, the two environments can exhibit differences in selection bias and attrition rates due to the differing requirements in time commitments, ease of withdrawal, and required hardware on the participant end (Arechar et al., 2017). It should be acknowledged then that the participants in this study were only able to participate because they had access to the Internet and a device on which to perform the task, which may have had a self-sampling effect on the chosen population.

Authentic Context During Task

Multiple participants attempted to apply real-world context to their flyers. Most notably, several participants factored in the existence of the COVID-19 into their information choices or target format. For example, when participant A2 realized that Ripley's Aquarium of Canada was closed at the time, he shifted his focus from active programs at the aquarium to the virtual tours they offered via webcam and COVID regulations. Participants A33 and A24 used a similar strategy due to the lockdown that was ongoing at the time. Participant A12 wrote some of his own copy for the brochure that acknowledged the hardships of COVID to potential customers.

Some participants also used information gained from the website to adjust the task instructions. As stated, the task said that the brochures were to "hand out at popular tourist locations in Toronto," but that might not have been a viable marketing strategy while the aquarium was closed. However, once some participants realized that highlighting virtual tours seemed like the most logical option, they switched their focus from print format to digital format. Participant A33 linked directly to various webcams that the aquarium was highlighting as though she were creating a digital brochure. Participant A2 used a similar tactic to highlight virtual tours. Near the end of his session, after asking the researcher if the brochure would be e-brochure or if it would be printed, he decided that treating it as a digital brochure was the best option. This behaviour indicates that, despite the finding and copying or inserting behavioural patterns described in earlier sections, the participants were unafraid to reinterpret the task instructions to fit the needs of the real-world environment in which it was created. This suggests that the task may have been effective as a situated learning tool (Young, 1993).

Conclusion

This study produced a few contributions to the literature. Firstly, this study suggests that participants who engaged more in the creation portion of the task, and less in the research portion, seemed to be more likely to develop technological skills in their chosen software application. Secondly, it has helped produced suggestions and task design recommendations for future studies. Finally, this study produced a coding rubric for the measuring and evaluation of technological and informational skill demonstrations in digital skill assessment studies.

The findings indicate that creating states of uncertainty may be an important catalyst for participants to begin using the Internet to solve technological problems, but they were not able to meaningfully connect search engine usage to technological skill development. While few strong findings were uncovered in this study, several avenues for future research can be recommended, which made this research project resemble a pilot study. One valuable result of this study is that the coding scheme used in the video analysis, which was developed through analysis of participant behaviour, can be re-used for future studies. Recommendations derived from this study can be broken down into 3 parts (study level, task level, data categorization level), and they are summarized below.

The first recommendation would be changes on the study level. A study performed over a longer time span than a single session may be better suited to study technological skill development. Such a study would allow for multiple periods and modes of reflection over longer time frames. It would also allow more time for participants to take ownership over their creations, determine problems, and produce solutions. Data sets produced from such a study would also be much richer and suited for prolonged engagement in qualitative data collection (Guba, 1981). It might also allow for an increased variety of software applications, which could help study software application choice as a variable. Finally, prolonged engagement might also allow researchers to see how participants use technology in their day to day lives and in larger, more complex activities. It is highly unlikely the learning process can be captured during a single, short research task (Kuhlthau, 2004).

The second recommendation is that future studies make some changes to the task design. There are multiple ways that this could be accomplished with varying degrees of practicality and effort required from the research. Two key changes that were discussed would be to remove the pre-provided example brochures (or example materials in general for other studies) and to test the effect of a reflection period intervention on skill development. The goal in applying these changes would be to allow for more diverse information searching behaviour and increased ownership of the task problem by removing implied strategies from the task description (Watts, 1991; Savin-Baden, 2000).

The third recommendation is to refine or redefine the sets of variables measured in technological skill development studies. In constructionism, the created object (in this case the brochure) should have meaning to the learner (Papert, 1993; Cano et al., 2015). Watts (1991) reiterates this concept by stating that learners should have ownership over what they learn. For this reason, when using participants in pre-designed research tasks, it may be worthwhile to also attempt to measure the relevance of the task to the participant’s professional or personal interests. For instance, if a participant cannot relate the task to their own knowledge domains, that may be a barrier to skill development that is otherwise not measured in this study (Herrington et al., 2006). This could be done by requesting that the participants theorize new usages of the task software or developed skills that could assist them in their professional or educational practice.

Some additional variables to measure may be the variety of websites searched and the types of the information searched, which could help to understand how research environment time is spent. It may be worthwhile to simplify interpretations of the post-task questionnaire items to help make the results more reliable. Importantly, it may be helpful to map post-task questionnaire items to technological and information competencies. This could help ensure the trustworthiness and clarity of participant responses, and it could provide more avenues for meaningful correlation between questionnaire items. Similar types of competency mapping have been done with the DCP questionnaire used in this study (Blayone, 2017).

Overall, the findings in this study are tentative for three reasons. Firstly, the sample size is very small, and the learning task represents only a small time period for participant technological skill development. Longer research times would be needed to recreate a creation task more accurately. Secondly, since much of the demographic data was lost prior to analysis, any transferability of these findings based on demographics would be impossible. Thirdly, the participant behaviour during the task was not fully representative of a complex, constructivist learning experience. Participants did not display much ownership of the task (Watts, 1991), opting instead to follow archetypes provided by the task. It is the hope that this paper can help provide guidelines and insights for future studies on information searching and technological problem-solving.

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Appendices

Appendix A. Study Materials and Approval Notices

A1. Live Session Task Instructions

You have been asked to create a professional-looking brochure in Microsoft Word to hand out at popular tourist locations in Toronto. See below to view two example brochures.

Click here to view example brochure 1

Click here to view example brochure 2

Create a new brochure for Ripley's Aquarium of Canada. Information you may need can be found at https://www.ripleyaquariums.com/canada/.

You may use the Internet to help you create the brochure. You have 60 minutes to create your brochure. Please speak aloud your thought process while you are working. This means explaining why you are performing any actions, or reasoning behind your decision-making. You may be periodically reminded to speak aloud if there are sequences of prolonged silence.

A2. Phase 2 – Post-Task Survey

1. My brochure is a useful resource for information.
    a. In your own words, explain why or why not you believe your brochure is a useful resource.
    b. 1 – Strongly Disagree; 2 – Disagree; 3 – Neither Agree Nor Disagree; 4 – Agree; 5 – Strongly Agree
2. My brochure looks professional
    a. In your own words, explain why or why not you believe your brochure looks professional.
    b. 1 – Strongly Disagree; 2 – Disagree; 3 – Neither Agree Nor Disagree; 4 – Agree; 5 – Strongly Agree
3. I learned new skills in Microsoft Word
    a. In your own words, describe the skills you developed, if any.
    b. 1 – Strongly Disagree; 2 – Disagree; 3 – Neither Agree Nor Disagree; 4 – Agree; 5 – Strongly Agree
4. I experienced difficulty locating relevant information.
    a. If able, identify any information you intended to find, but had trouble locating.
    b. 1 – Strongly Disagree; 2 – Disagree; 3 – Neither Agree Nor Disagree; 4 – Agree; 5 – Strongly Agree
5. I experienced difficulty applying information I found online to my Word document.
    a. If able, identify any information you had difficulty applying to your Word document.
    b. 1 – Strongly Disagree; 2 – Disagree; 3 – Neither Agree Nor Disagree; 4 – Agree; 5 – Strongly Agree
6. I was given enough time to complete the research task.
    a. If you did not finish your task, were you satisfied with your task progress?
    b. 1 – Strongly Disagree; 2 – Disagree; 3 – Neither Agree Nor Disagree; 4 – Agree; 5 – Strongly Agree

Appendix B. Example Noldus the Observer X14 Live Session Visualizations

B1. A13

B2. A23

Appendix C. DCP Question Set

Technical Order	**Q1**	To create/edit electronic documents (word processing, presentations, spreadsheets)
	Q2	To create/edit voice recordings (podcasts, voice memos)
	Q3	To create/edit multimedia items (photographs, movies, slideshows)
	Q4	To manage any of my accounts (email, bank, phone, videochat service, TV/movie service, etc.)
	Q5	To manage or operate other devices (home entertainment system, thermostats, lights, etc.)
Social Order	**Q6**	To communicate with others using text chat (SMS, MSN,...)
	Q7	To communicate with others using audio (Skype, MSN, phone)
	Q8	To communicate with others using video (Facetime, MSN, Skype)
	Q9	communicate with others using email
	Q10	To use social networking systems (Facebook, Google+, LinkedIN, Twitter, etc.)
	Q11	To use collaboration/shared document tools (Google Drive, Dropbox, etc.)
	Q12	To share my works and ideas publicly (blogs [Wordpress], photo sharing [Flickr, Picasa], Pinterest, etc...)
Informational Order	**Q13**	To access digital maps (MapQuest, GoogleMaps) or a GPS (TomTom) to find my way or to get directions
	Q14	To search for articles on the Internet
	Q15	To search for short videos (i.e.: YouTube) on the Internet
	Q16	To search for and download movies from the Internet
	Q17	To search for and download music from the Internet
	Q18	To search for and download books (text and/or audio) from the Internet
	Q19	To use an aggregator to automatically collect and organise documents (news aggregators, data feeds, RSS feeds, media aggregators etc.)
Epistemological Order	**Q20**	To use and share a calendar/personal agenda
	Q21	To create and use concept maps or mind maps
	Q22	To create, modify and use plans or other diagrams
	Q23	To sort large amounts of data
	Q24	To produce graphs from numerical data
	Q25	To do complex calculations
	Q26	To do some form of programming to automate certain processes (macros, scripts, robotics, any programming language, etc.)