Readiness for digital learning: Examining self-reported and observed mobile competencies as steps toward more effective learner readiness assessment

by

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Abstract

This mixed-methods study explores a digital-competencies survey tool for probing the readiness of higher-education students for digital learning, in three steps. First, it develops a methodology for capturing and analysing authentic, digital-learning activity, and relating this activity to reported digital competencies. Second, it explores situational factors shaping human-computer interactions through video-based, case-study analyses. Finally, it proposes a threshold approach to self-reported digital competencies, which may help identify students requiring greater preparedness for optimal functioning as digital learners.

Quantitative findings include generally strong, positive correlations between self-reported competencies and performance quality. Qualitative case-study analyses highlight four sets of situational factors influencing performance: (a) task/scenario difficulty; (b) comfort with device; (c) engagement, frustration and fatigue; and (d) persistence and activity-completion strategy.

In the end, this study recommends the General Technology Competency and Use instrument as a promising tool for probing participant readiness for digital learning, and offers methodologies for future performance studies.

Keywords: digital learning readiness; digital competency; mobile learning; general technology competency and use; online learning; higher education; student readiness.

Dedication

This work is dedicated to my research and life partner, Dr. Olena Mykhailenko, who tirelessly and patiently, offered her complete and unconditional, intellectual and emotional, support throughout the entire course of this experience. Whether sharing a claustrophobic, UOIT research space, or a patch of sand along a softly-flowing Dnieper, she always created a supportive space where I could be (the best) me.

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1 Introduction

The integration of digital technologies at institutions of higher education has profoundly influenced formal learning on a global scale. There were more than 40 million higher-education students in the world taking one or more of their classes online in 2013 (Atkins, 2013). Allen & Seaman (2016) highlight that over 28% of students enrolled in degree-granting institutions in the United States took at least one online course in 2014. Locally, in Ontario, over 20,000 online courses are available through institutions of higher learning (Contact North, 2016). Looking beyond these numbers, *digital learning* functions as an umbrella term inclusive of online, distance and blended learning (Siemens, Gašević, & Dawson, 2015), and incorporating mobile learning (Alhassan, 2016; Crompton, Burke, Gregory, & Gräbe, 2016; Shroff, Keyes, & Linger, 2015; Soykan & Uzunboylu, 2015; Viberg & Grönlund, 2015). Moreover, it accommodates diverse technologically-mediated educational practices, shaped by context, socio-political values, epistemologies and learning models (Aparicio, Bacao, & Oliveira, 2016).

As examples of this variability, some programs of digital learning support individualized modes of education with optional forms of cooperation (Dalsgaard & Paulsen, 2009; Paulsen, 2003, 2008). Others emphasize transactional learning in which collaboration functions to reduce confirmation bias and build worthwhile knowledge (Garrison, 2016). Still others leverage digital technology to correct power imbalances in traditional education, and facilitate the development of learning communities to address authentic problems (Blayone, vanOostveen, Barber, DiGiuseppe, & Childs, 2017; vanOostveen, Davidson, Naffi, Price, & Blayone, 2016; vanOostveen, DiGiuseppe, Barber, Blayone, & Childs, 2016). Taken together as a general milieu, digital learning achieves success—which may be defined, for example, in terms of program sustainability, participant satisfaction, or numerous other performance outcomes (Bates, 2015)—when the socio-economic environment, supporting digital infrastructure, host institutions, and human participants are well prepared, or put more simply: *ready*.

As reviewed below, the research literature addressing readiness for digital learning is broadly international, with researchers from several developed and developing contexts seeking to align systems of higher education with an increasing global, and digital, knowledge society (Blayone, Mykhailenko, et al., 2017). This is the conceptual starting point for the current study, whose general purpose is to address a gap in the readiness research by leveraging (a) the observational affordances of the EILAB's digital-research infrastructure (EILAB, 2016); (b) an established conceptual framework developed by EILAB researchers (Desjardins, Davidson, Blayone, vanOostveen, & Childs, 2015); and (c) techno-methodological approaches derived from digital-competency and human-computer interaction researchers, including multi-perspective audio-video capture of real-time human-computer interaction, and synchronized, video analysis using The Observer XT scientific software (Noldus Information Technology, 2016). The structural logic, procedures and goals supporting this study may be summarized as follows.

Within the frame of readiness for e-learning, this investigation begins by reviewing the state of the conceptual and operational literature (**Section 2.1**), and the position and strength of digital competencies, as readiness factors, within it (**Section 2.2**). Through processes of literature analysis and synthesis, it is demonstrated that digital competencies represent a highly significant cluster of readiness factors at the "micro-level" (related to human participants, rather than infrastructure or national socio-economic climate, for example). However, it is argued that a major gap exists in micro-level readiness research. Namely, it is dominated by self-report instruments that are rarely, if ever, triangulated with performance observations. To address this gap, and more fully explore digital competencies as a facet of readiness, this researcher selects a well-established framework, developed with the specialized (and tragically parallel) domain of digital-competency research. This is the General Technology Competency and Use (GTCU) framework, authored by Desjardins (Desjardins, Lacasse, & Belair, 2001), and developed by researchers associated with the EILAB (Desjardins et al., 2015) (**Section 2.3**).

The GTCU provides an established and reliable instrument for measuring multiple dimensions of competency (Desjardins, 2005; Desjardins et al., 2001). However, to date, GTCU researchers have described the reported general competency levels of groups, consisting mainly of students and teachers, without directly interpreting these descriptions in relation to observable, digital-learning performance (Desjardins & vanOostveen, 2015; DiGiuseppe, Partosoedarso, vanOostveen, & Desjardins, 2013). The challenge remained to relate self-report data and performance activity. This required a rigorous methodology for designing, capturing and analysing, authentic digital-learning activities, which could be mapped effectively to specific GTCU indicators.

Section 3 explores theoretical alternatives and current practices in the literature to model performance activity and observational design. Through secondary research, which identifies and organizes the choices previous researchers make to instigate and analyse performance activity, a conceptual apparatus is developed for designing a methodology. This apparatus moves beyond the objectivist "perceived"-versus-"actual" discourse that still pervades some studies. With this apparatus in place, the empirical project, focused on comparing self-reported and performed digital competencies, as facets of readiness for online learning, is described (**Section 4**). The research questions address the degree of correspondence between GTCU self-reports and the assessed quality of digital-learning activity, and what this means for using the GTCU instrument as a tool for probing participant readiness in contexts of higher education.

To pursue this question empirically, a sample of 15 individuals from UOIT were recruited. Self-reported, digital-competency data were collected via the GTCU survey instrument, and performance activities were instigated, captured and analysed using the digital affordances of the EILAB. Data from an optional speak-aloud protocol, observational field notes, and post-activity interviews were also collected to provide an interpretive context for the rich, audio-video data, captured from multiple perspectives and depicting: (a) hand-device interactions and device-screen activity; and (b) facial expressions. The latter was critical for observing and interpreting changes to a participant's level of comfort, motivation, and emotional valance throughout the activity.

Apple iPad Air and Samsung Tab 2 devices were selected for participant activity owing to a call for greater focus on mobile devices in performance research (Litt, 2013; Van Deursen, Helsper, & Eynon, 2015). Three authentic scenarios were designed with six constituent tasks mapped to specific GTCU indicators, to (a) simulate "real world" academic activity, and (b) facilitate meaningful comparisons of task performance to reported competencies. Participants were randomly assigned to one of three participant groups. All activity was captured using Noldus Media Recorder and a custom, technological setup in the EILAB, featuring two strategically-positioned, tri-pod mounted, HD cameras and an ambient micro-phone.

Analyses of the data were conducted in five phases. First, descriptive statistics of the survey data were generated in SPSS, and transferred to a correlational matrix in Excel. Second, the audio-visual recordings of each participant's real-time activity were reviewed and coded in Noldus The Observer XT, and scored (using a process quality-assessment rubric). The total time for scenario completion was noted, and a score was also assigned to the activity artefacts (using an outcomes-based, quality-assessment rubric). Third, video recordings of the post-activity interviews were reviewed, and key data extracted, including perception of scenario difficulty, levels of comfort performing certain tasks, and a self-assessment of readiness for digital learning using a tablet. The process and outcomes scores, key demographic information, reported difficulty and general readiness scores, and total time on scenario were transferred to the correlational matrix for analysis. Fourth, using the performance timeline data developed in *The Observer XT* and conducting a second review of the audio-video records, five, qualitative case-studies were conducted to address inconsistencies in correlational patterns and achieve deeper exploration of readiness factors beyond the reach of the GTCU instrument. Finally, taking all the data gathered from this study, and by positioning each individual in relation to reported competencies and corresponding quality of performance, a GTCU threshold was proposed—below which some students appeared "at risk" in terms of general preparedness for optimal functioning in a context of digital learning.

In the end, this study offers a new conceptual frame, and tentative set of methodological procedures, for interpreting the self-reported, digital competencies of individuals as indicators of general readiness for digital learning. Moreover, it provides insights into how research, based on self-reported digital competencies using the GTCU instrument, might be extended to infer an individual's generally ability to function effectively in digitally rich environments, particularly where mobile is part of the mix. Although, this study is a modest step forward—owing to small sample size, time constraints, and an exploratory orientation—it offers important bridges between self-reported digital-competency research, and the richly international domain addressing readiness for digital learning.

2 Literature Review

The following literature review draws on two bodies of international research. The first conceptualizes and assesses readiness for digital learning, an umbrella term for e-learning, online learning, distance education, technology-enabled learning, etc. (Siemens et al., 2015). The second conceptualizes and measures digital competencies, considered a key competency for effective functioning in a digital society (Ala-Mutka, 2011). It is demonstrated that readiness research is a vital international domain recognizing digital competencies as significant variables. However, within this domain, there is limited categorization and inconsistent operationalization of such competencies. Therefore, the second body of research is positioned as offering models and methods for addressing gaps in the former, and suggesting ways to strengthen explorations of readiness.

2.1 Readiness for Digital Learning

2.1.1 Origins

Readiness for digital learning has roots in at least two research traditions: learning psychology, and technology-systems development. Working within the young field of learning psychology in the early 20th century, the American psychologist Edward Thorndike (1874-1949), introduced the idea of “readiness” to account for observed differences in the intensity of human responses to stimuli which would be expected, all things being equal, to generate the same intensity of response (Thorndike, 1932). Thorndike developed this early behaviourist observation into a general “law” of learning, interpreted by Knowles as "the circumstances under which a learner tends to be satisfied or annoyed, to welcome or to reject" an educational intervention (Knowles, 1973, p. 20). This law became a staple of behaviourist educational psychology at the level of individual learners (Allen, 2007).

Several decades later, in the 1970s, and with reference to the development and utilization of high-technology systems, engineers of the National Aeronautics and Space Administration (NASA) introduced the concept of “technology readiness levels” to determine the maturity of technology systems, their current capabilities, and the economic and human (engineering) requirements for effective use (Sullivan, 1970). Readiness assessment, in this sense, functioned at the organizational level of analysis to address performance characteristics of technologies and their human counterparts as key facets of complex and expensive systems, which were expected to provide a significant return on investment.

By the 1990s, as a synthesis of these earlier readiness traditions, models and instruments, like those developed by the Computer System Policy Project, were introduced to assess the “e-readiness” of individuals, groups and even entire societies for digital environments and processes such as e-commerce (Sopu, Chisaki, & Usagawa, 2016). During the latter part of the same decade, "academic readiness" appeared in a pioneering Australian study of Warner, Christie & Choi (1998), exploring distance education for vocational training (Hung, Chou, & Chen, 2010). Similarly, with reference to the use of computer-conferencing environments in higher education, Gunawardena & Duphorne (2001) conceptualized and operationalized "learner readiness" with extensive reliance upon the work of Eastmond (1994). In summary, by the mid-1990's, the idea of "readiness" for using information and communication technologies (ICT) successfully in educational contexts, was "in the air."

2.1.2 Terminology and definitions

In the research literature since 2000, "e-readiness" appeared regularly to address levels of general ICT adoption and usage in a given context (Ghavamifar, Beig, & Montazer, 2008; Parasuraman, 2000), or for a specific purpose, such as e-commerce (Bui, Sankaran, & Sebastian, 2003), e-government (Alaaraj & Ibrahim, 2014) or e-learning (Borotis & Poulymenakou, 2004). Within educational contexts specifically, readiness for digital learning is addressed through a cluster of related constructs including e-learning readiness (Mosa, Naz'ri bin Mahrin, & Ibrrahim, 2016; Rohayani, Kurniabudi, & Sharipuddin, 2015), online-learning readiness (Horzum, Kaymak, & Gungoren, 2015), online readiness (Farid, 2014), mobile-learning readiness (Lin, Lin, Yeh, Wang, & Jansen, 2015), e-readiness (Ilgaz & Gülbahar, 2015), e-learner readiness (Leigh & Watkins, 2005) and e-learning acceptance (Teo, 2010). This tight family of constructs is well represented in English-language scholarship around the world with contributions from academics at institutions in Australia, Hong Kong, Indonesia, Iran, Malaysia, Nigeria, Taiwan, Turkey, UK and USA, among others. It is noteworthy that some researchers preferred "preparedness" to readiness as a way to shift emphasis from traits considered closely linked to personality, to those behaviours that are observable, measurable and *can be learned* (Parkes, Stein, & Reading, 2015).

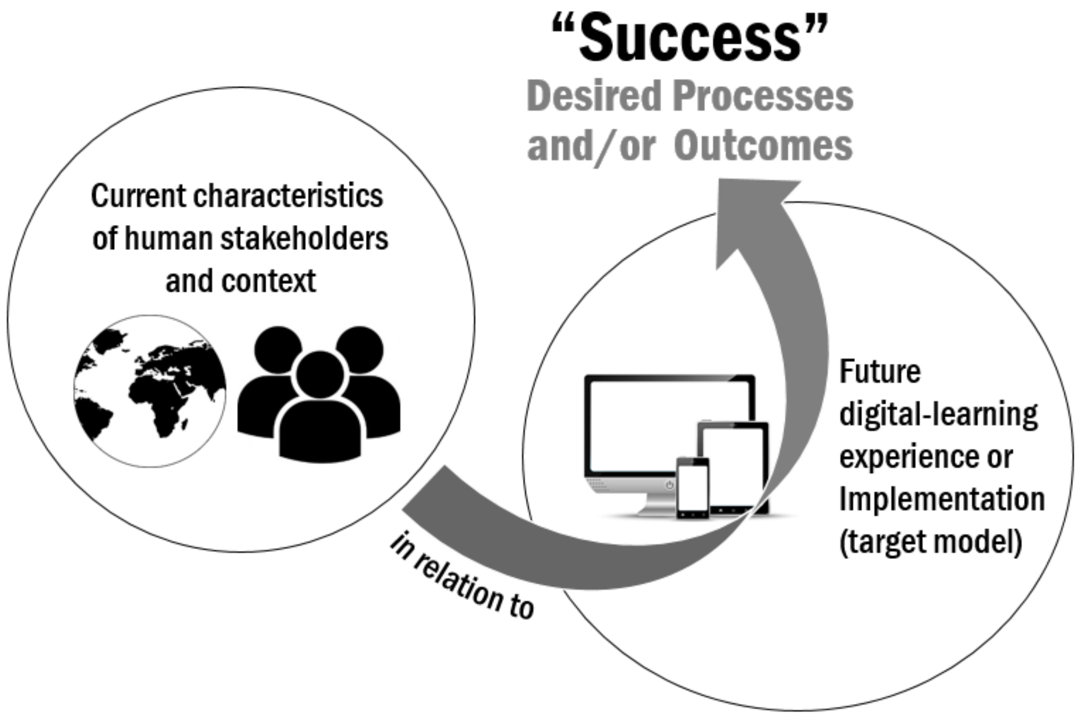
Definitions of educational e-readiness may typically be assigned to one of three types: (1) general, (2) organizational, or (3) human stakeholders (e.g., students and teachers). One *general* definition defines electronic readiness as a measure of the degree to which a nation, country or economy may be ready, willing or prepared to obtain benefits from information and communication technology used in a context of education (Sopu et al., 2016). *Organizational* definitions view readiness as an assessment of factors to be considered if organizations are to be successful with the introduction of an e-learning strategy (Farid, 2014; Odunaike, Olugbara, & Ojo, 2013); the measure of the degree to which an educational community may be eager and prepared to experience benefits from using ICT for learning (Ilgaz & Gülbahar, 2015); or, the ability and capacity of an educational institution's stakeholders, including students, IT support staff, teachers and administrators, to integrate ICTs into their practices of teaching, learning, research and community development, and manage social challenges that create digital divides (Chipembele, Chipembele, Bwalya, & Bwalya, 2016). Although lengthy, this last definition, authored in Zambia, introduces a vital socio-economic aspect, highlighting inequalities of technology access. This aspect is vital to advancing socially-responsible conversations about readiness. At the same time, it must be emphasized that technology access is a necessary but insufficient condition for effective use (Eastin & LaRose, 2000; Van Deursen & Van Dijk, 2011a, 2014).

At the level of individual stakeholders, the following are presented in chronological order beginning with two early definitions. The first, from 1998, and relating to readiness for "flexible delivery including on-line learning" includes three facets: (a) student preferences for form of delivery: (b) student confidence in electronic communication for learning, and (c) a learner's ability to engage in autonomous learning (Warner et al., 1998). A second, from 2000, defines technology readiness more generally, as an individual's propensity to embrace and use technologies for accomplishing a goal, or an overall state of mind resulting from psychological enablers (e.g., optimism and innovation) and inhibitors (e.g., discomfort and insecurity) that form a predisposition towards technology use that determines behaviour (Parasuraman, 2000).

More recent stakeholder-level definitions depict readiness as: relating to factors a distance student brings to the learning which influences its success (Gunawardena & Duphorne, 2001); the conditions that are essential to create a successful online learning venture for both educators and students (Schrum & Hong, 2002); those personal qualities of students that directly impact satisfaction with online learning, and which can be distinguished from environmental variables such as the specific technologies or pedagogies implemented by an institution (Pillay, Irving, & Tones, 2007); the level of technology adoption of individuals for informal and formal learning purposes with the expectation that adoption will provide learners with significant benefits (Hussin, Manap, Amir, & Krish, 2012; Lin et al., 2015); and finally, the extent to which users are prepared to apply their e-learning experience within an online learning environment comprised of e-learning software, course design or pedagogy, and the computer-mediated interactions between participants during preparation, delivery and completion phases (Gay, 2016).

These stakeholder-level definitions highlight different actors (e.g., students, educators), desirable attitudes (e.g., optimism and acceptance), learning contexts (e.g., formal and informal), environmental components (e.g., software and course design) and outcomes (e.g., learning satisfaction and "significant benefits"). Yet, taken together, all the definitions presented in this literature review present a common deep structure (functioning as a family resemblance), consisting of (a) current stakeholder/contextual characteristics, (b) a future digital-learning implementation, and (c) some idea of success. Of course, at the level of details, there remains significant variation in (a) the characteristics thought to be most significant/influential, (b) the nature of the future digital-learning activity (i.e., the target model), and (c) how success is defined.

Figure 1. The Deep Structure of Readiness for Digital Learning



2.1.3 Purposes and organizational themes of readiness research

The purposes (or problems) undergirding international readiness research are many and multifaceted. Some researchers are most concerned with general adoption of digital technologies as an avenue of educational reform and innovation (Peng, Tsai, & Wu, 2006). Others, who function in contexts of high digital adoption, worry about the sustainability of exiting digital-learning programs and the related issue of student completion rates (van Rooij & Zirkle, 2016). Still others seek to anticipate the cognitive and emotional challenges facing students who are transitioning from face-to-face to digital-learning environments (Schrum & Hong, 2002). Importantly, some pursue readiness research to increase learner satisfaction and improve the design and quality of the digital-learning experience (Ilgaz & Gülbahar, 2015). In short, researchers approach readiness both from the perspective of institutional sustainability and the sometimes quite different interests of learners.

Beyond the instigating problems guiding researchers, three dominant themes help organize the research. First, as we encountered by sampling definitions of readiness, the research literature can be divided into macro- and micro-level analyses (McGill, Klobas, & Renzi, 2014; van Rooij & Zirkle, 2016). Macro-level analyses address broad factors at the organizational, regional or even national levels (Beetham & Sharpe, 2007; Bui et al., 2003). Addressing readiness at the level of nation is particularly common in contexts where digital learning is in the early stages of development, such as in developing nations (Aung & Khaing, 2016; Hrtoňová, Kohout, Rohlíková, & Zounek, 2015; Sopu et al., 2016). Importantly, even at this level of analysis, which includes factors such as national Internet penetration and mobile subscribers, some micro-level factors such as digital-use patterns and the general abilities of particular population segments are sometimes included. Micro-level readiness research, however, fixes its attention on more fine-grained characteristics of human stakeholders in specific educational contexts, with both students (Dray, Lowenthal, Miszkiewicz, Ruiz- Primo, & Marczynski, 2011; Parkes et al., 2015) and teachers (Gay, 2016; Hung, 2016) garnering significant attention. In some cases, a specific student demographic, such as adult learners, is the chosen focus (Ilgaz & Gülbahar, 2015).

A second organizing theme relates to the *multi-dimensionality* of readiness. At each level of analysis, researchers have conceptualized several dimensions (and often sub-dimensions) of readiness either (a) deductively, through the development of readiness frameworks (Demir & Yurdugül, 2015; Mosa et al., 2016) or (b) inductively, through grounded-theoretical analysis of the empirical literature (Al-Araibi, Mahrin, & Mohd, 2016; Rohayani et al., 2015), analysis of documents from institutions offering online learning (Schrum & Hong, 2002), or by surveying those involved in both successful (defined as continuing) and unsuccessful (defined as defunct) e-learning initiatives (McGill et al., 2014). Among the identified factors, a significant distinction can be made between factors related to learning dispositions and abilities (e.g., self-regulation, self-direction, etc.), on the one hand, and technology perceptions and abilities, on the other hand.

A third organizing theme, relates to *level of specialization*, particularly among research conducted in contexts where digital learning is well developed. Three emerging avenues of specialization are observed in the literature, including those that address: (a) mobile technologies exclusively (Hussin et al., 2012; Lin et al., 2015; Shorfuzzaman & Alhussein, 2016; Yeap, Ramayah, & Soto-Acosta, 2016), (b) specific forms of learning such as collaborative-constructivist (van Rooij & Zirkle, 2016), or (c) particular national, cultural or socio-economic contexts (Alaaraj & Ibrahim, 2014; Chipembele et al., 2016). However, it is still the case that the bulk of the readiness literature addresses digital-learning environments as a general "milieu" to be distinguished primarily from traditional, in-class education, rather than a set of diverse constructs to be distinguished amongst themselves.

2.2 Situating Digital Competencies as a Key Dimension of Readiness

The previous section highlighted the essential contours of readiness literature. Synthesizing the results, readiness for digital learning is a broadly international, multi-level and multi-factor research agenda. It is aimed at conceptualizing and measuring/assessing how prepared individuals, groups, institutions or countries are to develop, or participate in, technology-mediated learning, with a view towards successful outcomes. Such outcomes may be defined from the perspective of social development, technology adoption, program and learner continuation (low drop-out rates), measured learning outcomes, or participants' (e.g., students' or teachers') level of satisfaction. This section focuses attention on establishing: (a) the relative position of digital competencies as a factor in the research, and (b) the manner in which digital competencies are operationalized and measured.

2.2.1 Nature and strength of digital competencies as readiness factors

A thorough analysis of digital competence and closely related constructs (e.g., digital literacy, digital skills, and e-competence) was performed by Ala-Mutka (2011) as a contribution to the EU's DIGCOMP project (Ferrari, 2012, 2013; Janssen & Stoyanov, 2012; Pérez-Escoda & Fernández-Villavicencio, 2016; Vuorikari, Punie, Gomez, & Van Den Brande, 2016). At the highest level of abstraction, digital competencies are defined as *sets of knowledge, skills and attitudes relating to the purposeful and effective use of digital technologies* (Ala-Mutka, 2011). Provided by a leading authority in the field, this definition is adopted to review the readiness literature and explore the nature and strength of digital competencies as readiness factors.

Four recent literature reviews provide a starting point (Al-Araibi et al., 2016; Demir & Yurdugül, 2015; Islam, Beer, & Slack, 2015; Mosa et al., 2016). The systematic review of Al-Araibi et al. (2016), conducted within a technology university in Malaysia, seeks to identify the most significant technology-related factors of e-learning readiness in the macro-level empirical research. Seventeen studies dated from 2004 to 2013, drawn from a variety contexts, are selected for analysis. Pursuing a grounded-theory approach to content and thematic analysis, "ICT skills" and "attitudes towards ICT" of students and teachers emerge as highly significant factors—mentioned in 15 studies. However, because they are more closely related to people than technology, they are bracketed out, and the discussion focuses on technology factors such as hardware, software, connectivity, security, system flexibility and technical staff (Al-Araibi et al., 2016). It is unclear why (human) technical staff are not also excluded as "people factors." Regardless, this data, drawn from an extensive sweep of the literature, highlights the strength of digital-competency-related factors, even when the researchers pursue a technology perspective.

A second study from the same research group surveys existing e-learning readiness frameworks (Mosa et al., 2016). Ten frameworks are selected from several national contexts including the UK, Greece, Turkey, Iraq and Uganda. Constituent dimensions from each framework are gathered, organized, listed and counted to establish those with the greatest frequency. The top factor, labelled "technology" appears in all ten frameworks—the only factor to achieve this coverage—and human technology skills figure prominently among its sub-dimensions. The authors conclude that this skills sub-factor is vital for successful e-learning, and a lack of such skills will likely result in participant resistance to technology-rich environments.

A broader systematic review by Turkish scholars, includes 25 frameworks divided into three groups, addressing: (a) readiness of learners (12 models), (b) teachers (7 models), and (c) institutions (10 models) (Demir & Yurdugül, 2015). For each group, the constituent factors are organized, and their distribution assessed. Technology competency is found to be the strongest factor in relation to both teacher readiness (included in 100% of the models) and learner readiness (included in 83% of the models). Technology-competency factors also appear in 50% of the institutional readiness models. This last finding is significant because some technology-focused researchers exclude human factors as a matter of definition.

Finally, Islam et al. (2015) provide a deductive, narrative review of e-learning readiness research from the perspective of human stakeholders at institutions of higher learning (including technical staff), in relation to five types of challenges: learning styles and culture, pedagogy, technology, technical training and time management. With respect to technical training, it is argued that many students and teachers in university settings lack the motivation and digital competencies crucial to online learning. Therefore, the authors consider conceptualizing, measuring, and ultimately increasing technology experience and confidence, a vital priority for learning institutions.

As a group, these studies establish digital-competencies as a prominent complex of factors, considered highly influential for digital-learning readiness. Chipembele (2016) emphasizes this, finding individual technology skills and confidence of students and teachers to be more significant than organizational factors for assessing readiness, suggesting that where levels are low, organizational investments in digital-learning infrastructure are likely to be underutilized. Given the significance of digital-competency factors in the research, it is all the more vital to ask: How are these factors, consisting of constituent knowledge, skills and attitudes, operationalized and measured?

2.2.2 Digital competencies as readiness factors

To address this question, we turn to micro-level empirical studies. As we have seen, although macro-level research may include technology skills/competencies of human stakeholders (Alaaraj & Ibrahim, 2014), they are generally eclipsed by higher-level constructs such as national/organizational culture, sophistication and accessibility of technology systems, depth of IT support, and implementation strategy.

Since at least 2000, researchers in the higher education space, have developed, validated and applied micro-level, digital-learning readiness instruments, and for the most part, these instruments draw heavily upon constructs developed in earlier work on learning motivation and technology acceptance (Wladis & Samuels, 2016). McVay's (2001) Readiness for Online Learning (ROL) questionnaire offered a footing for several later studies, including that of Bernard, Brauer, Abrami, & Surkes (2004), which sought to apply and improve the original instrument. A very recent literature review (Wladis & Samuels, 2016) identifies 13 instruments developed since McVay's initial work up to the year 2011. Since that time, additional instruments have been developed, with more recent instruments seeking to address readiness in relation to specific contexts, types of technology devices and modes of learning (Hung, 2016; Lin et al., 2015).

For the purposes of addressing the operationalization and measurement of digital competencies as readiness factors, 10 instrument-development studies are reviewed here as representative samples. These include six studies listed by Wladis & Samuels (2016), an influential early instrument (Parasuraman, 2000), another developed in Turkey (Aydın & Tasci, 2005), and two specialized instruments addressing mobile-learning readiness (Lin et al., 2015) and teacher-specific readiness (Hung, 2016). (These last two instruments appear to represent emerging subdomains.) For each of the selected 10 instrument-related studies, all of which included batteries of validity and reliability testing, the following key data were extracted:

- Research identifiers (researcher, date and national context)
- Purpose of selected study
- Target audience
- Readiness factor model
- Items addressing facets of digital competency
- Total number and samples of items related to measuring digital competency
- A brief typological summary of these items including what specific phenomenon (e.g., frequency of use, confidence, level of ability) is being self-reported, and how (e.g., capabilities, declarative or procedural knowledge claims, feelings, likes, etc.)

- Key findings of relevance to the operationalizing and measurement of digital competencies as readiness factors.

These data are presented in Table 1 (pp. 14-16), in some detail, to (a) establish a sense of the strength and breadth of the constituent knowledge, skills and attitudinal constructs addressed by each instrument; and (b) the specific manner in which these constructs are operationalized as self-report items. This analysis provides enough data for identifying patterns and gaps.

To interpret this data, we focus on those factors addressing facets of digital competency, defined above, following Ala-Mutka (2011), as knowledge, skills and attitudes supporting purposeful use of digital technologies. Across the ten readiness instruments reviewed, the highest percentage of digital-competency items is 100% (Parasuraman, 2000; Watkins, Leigh, & Triner, 2004), and the lowest is 31% (Kerr, Rynearson, & Kerr, 2006). Across all the readiness instruments, the average concentration of digital-competency-related items is 64%. This finding is consistent with the strength of digital competency as a conceptual dimension in many readiness frameworks, as described above. Most of the remaining items relate to self-direction, self-regulation or desire for social interaction, all individual, online-learner constructs that play a prominent role in online-learning research (Garrison, 2011, 2016; Garrison & Archer, 2000). Indeed, in general, readiness for digital-learning research appears to split its attention between two distinct complexes of factors at the individual-level of analysis: digital competencies and learning characteristics.

Among the digital competency sub-factors, all the instruments, except one (Kerr et al., 2006), address attitudinal factors, with four instruments focusing exclusively on such factors (Hung, 2016; Hung et al., 2010; Lin et al., 2015; Parasuraman, 2000). Items related to self-efficacy or confidence of technology use predominates. With respect to the inclusion of attitudinal items, a significant outlier is the Test of Online Learning Success (TOLS) instrument (Kerr et al., 2006). For this instrument, all the items (representing direct, first-person, ability claims) were constructed to reflect a skill rather than an attitude owing to the general social-psychology finding of weak correlations between attitudes and behaviours (Kerr et al., 2006). Importantly, only four instruments address digital abilities, with one other instrument including direct, ability claims (Bernard et al., 2004). Other instruments present unsystematic sets of beliefs ("I think I would be able to…") (Watkins et al., 2004), knowledge and experience questions ("Do you know…" or "How often do you…") (Dray et al., 2011), or items related to technology access (Aydın & Tasci, 2005; Watkins et al., 2004).

Table 1: Comparison of Readiness Instruments

Research	Purpose	Group	Factors	Digital Competency Items with Samples	Typological Summary
Parasuraman, A. (2000), USA	Measure technology acceptance at the level of individual psychology.	General public	**1. Technology Optimism** **2. Technology Innovativeness** **3. Technology Discomfort** **4. Technology Insecurity** Related directly to the digital environment, four attitudinal factors, conceptualized as two drivers (1 and 2) and two inhibitors (3 and 4) of technology readiness.	36 items (**100%**) "You like the idea of doing business via computers because you are not limited to regular business hours." (Factor 1) "Other people come to you for advice on new technologies." (Factor 2) "Sometimes you think that technology systems are not designed for use by ordinary people." (Factor 3) "If you provide information to a machine or over the Internet, you can never be sure it really gets to the right place." (Factor 4)	Factors measured with second-person statements as indicators of four key attitudes. (ATTITUDES)
Bernard, R. M., et al. (2004), Canada	Predict academic success (grades) of students moving from traditional classrooms to distance education courses/programs.	University students	**1. Confidence in Digital Skills** **2. Beliefs about Internet-based Education** 3. Self-direction and Initiative **4. Desire for Interaction (Online and Generally)**	19 items of 37 total (8 F1, 8 F2, 3 F4; **51%**) "I am able to easily access the Internet as needed for my studies." (Factor 1) "I possess sufficient computer keyboarding skills for doing work online." (Factor 1) "I am comfortable communicating electronically." (Factor 2) "I am willing to actively communicate with my classmates and instructors electronically." (Factor 2) "I can work in a group during Internet activities." (Factor 3)	First-person, direct, self-assessment of procedural abilities and attitudes. Indicators relate to very basic technical and social, digital interactions, e.g., communicating electronically and online, keyboarding or composing text on a computer. (ABILITIES AND ATTITUDES)
Watkins, R., et al. (2004), USA	Measure an individual's perceived readiness to engage in distance education, a delivery method for instruction.	Participants from the US Coast Guard	**1. Technology Access** **2. Online Skills and Relationships** **3. Motivation (for Online Activity)** **4. Online Video/Audio** **5. Internet Discussions** **6. Importance to (Online Learning) Success**	27 items (**100%**) "I have access to a computer with an Internet connection." (Factor 1) "I think I would be able to take notes on a computer...or communicate effectively online." (Factor 2) "I think I would be able to complete my work even when there are online distractions." (Factor 3) "I think I would be able to take notes while watching video on a computer." (Factor 4) "I think I would be able to carry on a conversation…using the Internet." (Factor 5) "I feel that prior experiences with online technologies…are important to my success with [an] online course." (Factor 6)	A mix of first-person claims of current abilities and belief claims about future activities and skill applications. Items relate to a mix of basic technical, informational and social interactions. (ABILITIES AND BELIEFS)

Table 1: Comparison of Readiness Instruments (continued)

Research	Purpose	Group	Factors	Digital Competency Items with Samples	Typological Summary
Aydın, C. H. and D. Tasci (2005), Turkey	Prepare organizations in a developing country to assess readiness of employees for e-learning, defined as instructional content or learning experiences delivered or enabled by electronic technology, with a culturally appropriate instrument.	Business managers	1. People (Employees) Characteristics 2. Employees' Self-development **3. Employees' Technology Access and Abilities** 4. Employees' Level of Innovation	11 items of 30 total (**37%**) "Do you think your employees are able to access the Internet at work?" "Do your employees possess basic computer skills (such as keyboarding, using a mouse, creating, saving and editing files)?" "Do the majority of your employees accept any technological innovation...."	Indirect, assessment of employees' basic access, computer skills and attitudes (related to general acceptance). (ABILITIES AND ATTITUDES)
Kerr, M. S., et al. (2006), USA	Validate the Test of Online Learning Success (TOOLS) instrument, and explore predictors of student success over time in formal fully online university courses.	American undergraduate and graduate students	**1. Computer Skills** 2. Independent Learning 3. Dependent Learning **4. Need for Online Learning**	14 items of 45 total (11 F1, 3 F4; **31%**) "I am capable of learning new technologies." (Factor1) "I am capable of sending and receiving email." (Factor 1) "I can download new software when necessary." (Factor 1) "I need online courses because of my geographical distance from universities." (Factor 4)	First-person, direct self-assessment of current digital abilities focused on basic technical, informational and social skills. According to the authors, "items are constructed to reflect a behaviour rather than an attitude because social psychology research shows low correlations between attitudes and behaviours." (ABILITIES)
Pillay, H., et al. (2007), Australia	Develop and validate the Tertiary Students Readiness for Online Learning (TSROL) scale, focused on improving student satisfaction and institutional performance with online learning, defined as the provision of learning via ICT.	University students	**1. Technical Skills** **2. Computer Self-efficacy** 3. Learning Preferences **4. Attitudes Towards Computers**	17 total items of 20 total (7 F1, 6 F2, 5 F3; **85%**) "I know how to install software to support my learning using computers." (Factor 1) "I can troubleshoot most problems associated with using a computer." (Factor 1) "I feel confident in using computers to connect to the Internet." (Factor 2) "I like using computers for research." (Factor 3) "I enjoy working on tasks on a computer that I can do by following directions." (Factor 3)	First-person, direct, self-assessment of current technical skills, computer-related confidence and likes covering a range of technical, informational, computational and social interactions. (ABILITIES AND ATTITUDES)

Table 1: Comparison of Readiness Instruments (continued)

Research	Purpose	Group	Factors	Digital Competency Items with Samples	Typological Summary
Hung, M.-L., et al. (2010), Taiwan	Develop and validate Online Learning Readiness Scale (OLRS) instrument for college students so that instructors can design better online learning, described as using a mix of asynchronous and synchronous affordances, and offering both individual learners flexibility and opportunities for collaboration.	Online university learners	**1. Computer/Internet Self-Efficacy** 2. Self-directed Learning 3. Learner Control **4. Motivation for Online Learning** **5. Online Communication Self-Efficacy**	11 items of 18 total (4 F1, 4 F4, 3 F5; **61%**) "I feel confident in performing the basic functions of Microsoft Office programs." (Factor 1) "I have motivation to learn (online)." (Factor 4) "I like to share my ideas with others (online)." (Factor 4) "I feel confident in using online tools to effectively communicate with others." (Factor 5)	First-person, direct, self-assessment of confidence related to technical, informational and social interactions. (ATTITUDES)
Dray, B. J., et al. (2011), USA	Contribute a "rigorously validated" instrument to the field of research focused on readiness for technology-enabled formal learning in which at least 80% of learning activity takes place online.	University students	1. Learner Characteristics **2. Technology Capabilities**	18 items of 32 total (**56%**) "Do you know how to install software on your computer for course purposes?" "How often do you use the Internet?" "If you were viewing a website, indicate which of the following files you would know how to open, view and/or print..."	Variety of question types, addressing extent of technology access, frequency of use, general knowledge, and technology device preferences, primarily focused on communicational and informational interactions. (EXPERIENCE AND KNOWLEDGE)
Lin, H.-H., et al. (2015), Taiwan	Extend online-learning readiness research to consider an individual's psychological readiness for mobile learning, defined as incorporating mobile technologies into learning activities.	Students and professionals	**1. m-Learning Self-Efficacy** **2. Mobile Technology Optimism** 3. Self-directed Learning	14 items of 19 total (7 F1, 7 F2; **74%**) "I feel confident in using mobile systems to effectively communicate with others." (Factor 1) "I feel confident in knowing how a mobile learning system works." (Factor 1) "I like studying via mobile learning systems because I am able to study anytime." (Factor 2) "Mobile learning systems make me more efficient in my studying." (Factor 2)	First-personal, direct, self-assessment of confidence of very general technical concepts (e.g., "mobile learning system") and social interactions (e.g., "communicate with others"). (ATTITUDES)
Hung, M.-L. (2016), Taiwan	Develop and validate an instrument measuring the degree to which elementary and middle school teachers are willing to embrace e-learning, which requires that teachers as co-learners.	Taiwanese teachers	**1. Communication Self-Efficacy** 2. Institutional Support **3. Self-directed Learning with Technology** **4. Learning Transfer Self-Efficacy**	8 items of 18 total (4 F1, 1 F3, 3 F4; **44%**) "I feel confident in posting questions in online discussions." (Factor 1) "I feel confident in using online tools (email, discussion) to effectively communicate with others." (Factor 1) "I am distracted by other online services when learning online…." (Factor 3) "I am confident about applying learning from my online course to my teaching job." (Factor 4)	First-personal, direct, self-assessment of confidence related to general social interactions. (ATTITUDES)

In the end, it appears that aside from a general preference for attitudinal factors, there is little consistency between readiness instruments in how digital competencies are conceptualized and measured.

2.2.3 Limitations and gaps in current readiness research

Wladis and Samuels (2016) have asked if existing readiness instruments, including six of those reviewed above, are generally effective "doing what they claim"—which they, without consideration of alternative perspectives, interpret as (a) reliably predicting differential grade performance in online versus face-to-face courses, and (b) identifying students "at risk" of failing as colleges courses move online. Having reviewed 17 instruments and the degree to which their authors tested for validity and reliability, they find that existing instruments have undergone different types and levels of validation testing, and not all instruments have been used to predict course grades. This last finding is proposed as a significant problem.

A general disinterest in relating readiness directly to course grades is consistent with our findings. Of the 10 instruments compared, only two were assessed as predictors of course grades (Bernard et al., 2004; Pillay et al., 2007). A third (Watkins et al., 2004) was analysed in relation to levels of perceived learning of course participants, which hints at the fact that course grades need not be the only educational outcomes of interest to readiness researchers. Regardless, focused on establishing the value of readiness instruments to predict grades, Wladis and Samuels apply a "representative instrument"—a 12-item survey including three computer access/skills questions, and therefore, quite unlike those reviewed above—to a large American sample of college students interested in taking an online course (n=24,006). Through several statistical analyses, they find that this instrument, and "likely others similar to it" lacked predictive value in identifying students at high risk in the online environment. Moreover, and somewhat disturbingly, they find that surveying students with this instrument discouraged them from enrolling in online courses.

This latter finding deserves comment. From an EILAB perspective, it is vital for readiness research to avoid aligning itself with institutional agendas focused on discouraging or screening out students for participation in online courses (van Oostveen, personal communication, February 15, 2016). In our view, emphasis should be placed on the effective measurement of digital competencies as an avenue for (a) preparing and equipping all potential, online-learning participants (students, teachers, instructors, etc.) for effective use of technology affordances; (b) pursuing and adopting technology affordances well-aligned with learner interests, experience and motivation; and (c) engendering vibrant online communities of inquiry, in which digital technologies become transparent, and in this way, secondary to rich, collaborative learning as modelled, for example, by the Community of Inquiry framework (Garrison, 2016).

With that said, we turn to address a significant gap in current readiness research. Namely, there is great disjunction between how readiness researchers conceptualize and measure digital competencies, and how this is handled by digital-competency research specialists. The strength of this disjunction can be illustrated, for example, by comparing the reference lists of a few readiness articles—we randomly selected three from our review list (Dray et al., 2011; Hung, 2016; Lin et al., 2015)—to those appearing in a literature review of digital abilities measurement (Litt, 2013), which coverers a significant body of research (71 items) from 2002-2013. The only common references relate to the work of Bandura (1997) on self-efficacy, and a digital-competency study focused on self-efficacy (Eastin & LaRose, 2000). A much larger body of key research published over the past two decades and focusing on the development of multi-dimensional frameworks and the exploration, testing and comparison of measurement methodologies is not represented.

The precise demarcation of this specialized, digital-competencies measurement domain—which uses "competency," "skill," and "literacy" inconsistently (Litt, 2013), and sometimes interchangeably (Eshet, 2004)—is impossible to establish. However, the following list of researchers, studies and projects, are presented as notable contributions to the field, and taken together, a core cluster within the domain.

- The diverse and expansive, digital-skills measurement and methodological work of Hargittai and her graduate research team, formally centred in America, and now in Zurich, Switzerland (Hargittai, 2002, 2004, 2009; Hargittai & Hsieh, 2012; Hargittai & Shafer, 2006).
- The digital-literacy (or "digital thinking skills") framework and performance observation work of Eshet in Israel (Eshet, 2002, 2004, 2012; Eshet-Alkalai & Amichai-Hamburger, 2004; Eshet-Alkalai & Chajut, 2009, 2010) offering a particularly notable longitudinal study (Eshet-Alkalai & Chajut, 2009, 2010)
- The prolific, digital-divide and digital-skills frameworks, performance observation and instrument-development work of van Deursen and van Dijk based at Twente University in the Netherlands (Van Deursen, Courtois, & Van Dijk, 2014; Van Deursen, Helsper, & Eynon, 2014; Van Deursen & Van Dijk, 2010; Van Deursen & Van Dijk, 2011a, 2011b; Van Dijk & Van Deursen, 2014).

- The digital abilities conceptualization and measurement work of Helsper at the London School of Economics in the UK (Helsper & Eynon, 2013), recently joined by van Deursen (Helsper & Van Deursen, 2015; Helsper, van Deursen, & Eynon, 2015).
- The digital competency framework and instrument development work of Desjardins and van Oostveen in Canada (Desjardins, 2005; Desjardins et al., 2001; Desjardins & Peters, 2007; Desjardins & vanOostveen, 2015), conducted in a higher educational context of social-constructivist, fully online learning.
- The digital-competency assessment models and empirical studies of Cartelli and Calvani in Italy (Calvani, Cartelli, Fini, & Ranieri, 2008; Calvani, Fini, Ranieri, & Picci, 2012; Cartelli, 2010; Cartelli, Latium, & Cassino, 2014), which although not offering a single, consolidated conceptual framework, have been richly generative of research in the area, particularly through Cartelli's editorship of the *International Journal of Digital Literacy and Digital Competence* (http://www.igi-global.com/journal/international-journal-digital-literacy-digital/1170).
- The EU's expansive digital-competency project (Ala-Mutka, 2011; Ala-Mutka, Punie, & Redecker, 2008; Ferrari, 2012; Janssen & Stoyanov, 2012), which published its synthetic, conceptual DIGCOMP 1.0 framework specification in 2013 (Ferrari, 2013), and is now pursuing an extensive revision (Pérez-Escoda & Fernández-Villavicencio, 2016; Vuorikari et al., 2016).

Within this body of research, two key findings stand out as particularly relevant to this inquiry. First, there is a unanimous consensus that digital competency *cannot be adequately addressed as a unidimensional construct*. Technologies and related human practices are simply too diverse in today's digital world. Therefore, this body of research regards effective use of digital technologies in relation to multiple forms of interaction, including, for example, technical or operational, informational or content-related, and communicational or social—three dimensions shared by most frameworks. Knowledge, skills and attitudes, supporting purposeful, human-computer interaction in each dimension, are required for individuals to function effectively in particular contexts of use, such as education.

Second, although both attitudinal and behaviour dimensions of competency are considered vitally important, *neither self-reported confidence nor self-reported skills are viewed as especially reliable predictors of performance*. Of course, this issue becomes particularly troubling for those researchers who have not explored the relationship between specific self-report items and various types of performance activity set within the target context of use. By exploring relationships between self-reported competencies and performance data empirically, can expect to achieve richer and more reliable assessments of individual readiness for digital learning.

2.3 A Representative Digital Competencies Model

This study pursues richer and more reliable readiness assessment at the micro-level by adopting a framework and accompanying instrument from *within* the domain of digital-abilities research. The General Technology Competency and Use (GTCU) is a Canadian framework for conceptualizing and measuring *general* digital competency across educational, professional and personal contexts (Desjardins, 2005; Desjardins et al., 2001; Desjardins & Peters, 2007). Belonging to a cluster of frameworks, the GTCU:

- is an academic model developed by university-based research team.
- offers a theoretical and operational apparatus for conceptualizing and measuring digital competency.
- has reported its development, validation and application in peer-reviewed, academic journals.
- maintains currency/relevance, as demonstrated through ongoing development and international application.
- focuses on digital competencies relevant to multiple purposes and contexts of use (e.g., educational, professional and personal).

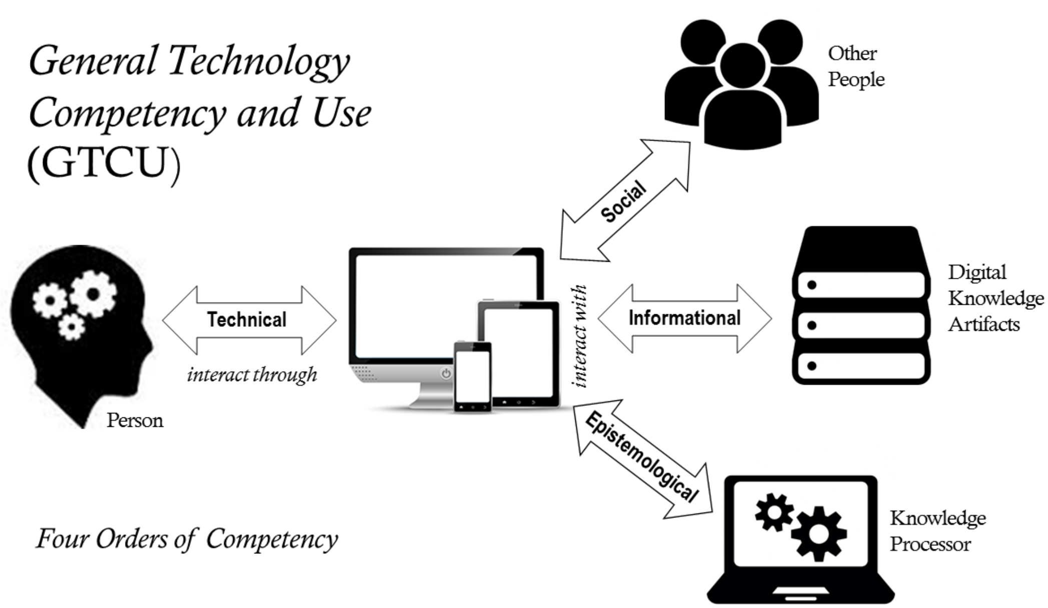
As presented above, two other frameworks with a full conceptual and operational apparatus, belonging to this cluster are: (a) the digital skills framework developed by van Deursen and van Dijk (A.J.A.M Van Deursen et al., 2014; Van Deursen & Van Diepen, 2013; Van Deursen, Van Dijk, & Peters, 2012; Van Dijk & Van Deursen, 2014); and (b) the digital literacy framework of Eshet-Alkalai (Eshet, 2004, 2012; Eshet-Alkalai & Chajut, 2009, 2010). For the purposes of assessing readiness for digital learning at the micro-level, however, the GTCU appears to offer significant advantages.

First, compared to van Deursen's framework, which focuses on functional skills required by citizens to access entertainment, health and government information online, the GTCU addresses a greater variety of interactions with more diverse levels of complexity. This is particularly the case with activities defined within the Epistemological Order. Second, compared to the Eshet's digital literacy or "thinking skills" framework, which offers complex dimensions and activities well-aligned with contexts of higher education, the GTCU offers a validated and reliable self-report instrument that has been used successfully in educational contexts. (Eshet's framework was operationalized exclusively through quality assessment of knowledge artefacts created through structured activities.) Finally, it has been applied successfully in numerous educational contexts to measure the digital abilities of students and teachers in Canada (Desjardins & vanOostveen, 2015; Desjardins, vanOostveen, Bullock, DiGiuseppe, & Robertson, 2010; DiGiuseppe et al., 2013) and Ukraine (Blayone, Mykhailenko, et al., 2017).

2.3.1 Conceptual dimensions of the GTCU

In order to achieve a categorized, parsimonious, stable, and multi-contextual (e.g., educational, professional and personal) model, Desjardins (2001) built the GTCU on the IEEE's definition of computer hardware: "physical equipment used to process, store, or transmit computer programs or data" (IEEE, 1990). In this way, he theorized three dimensions ("orders") of digital technology use: epistemological (process), informational (store) and social (transmit). Successful users of digital technology, develop specific knowledge, skills and attitudes (KSAs) in each of these dimensions aligned with the context of use and desired outcome, as described below. As shown in Figure 2, a technical dimension, addressing hardware and software operational skills, was added to the GTCU as a prerequisite for optimal functioning in the other dimensions.

Figure 2. Orders of the GTCU Framework



Epistemological competencies relate to those interactions in which humans assign cognitive (algorithmic) tasks to the computer. Although this once required programming skills, such tasks can be assigned using information-processing applications, including spreadsheets, concept-mapping tools, photo-manipulation programs, and personal planners. The key ingredients for epistemological (or "computational") competence are deep conceptual knowledge in a domain, and the ability to translate this knowledge into operational procedures using the functions provided by a computer application. Primary benefits relate to effective problem solving, hypothesis development, verification (Desjardins, 2005) and cognitive partnering (Jonassen, 1995).

Informational competencies relate to successful interactions between humans and information objects or knowledge artefacts. Based on the dimensional summary of Desjardins (2005), the most relevant KSAs may be organized into four groups. The first focuses on finding relevant information. This requires conceptual and procedural knowledge, and skills related to using search tools and building queries. A second group relates to assessing relevance, usefulness, reliability and validity. A third group involves the organization, comparison and synthesis of selected information with other data. Finally, in order to transform information into new knowledge, abilities related to production, revision and publication of information in a variety of media formats (e.g., text, images, and video) are required.

Social competencies address facets of digital communication, collaboration and publication. They include conceptual knowledge of contextually appropriate, human interaction, and procedural knowledge for successful communication using a variety of platforms (e.g., email, social media and video conferencing). Social-media applications, in particular, also require an ability to maintain appropriate online identities, and assess risks related to sharing personal data. The abilities to match tools with desired outcomes, exhibit patience with technical obstacles (such as delays in videoconferencing environments) and promote respect, trust, tolerance and mutual safety are also vital.

2.3.2 Operationalization of the GTCU

To date, the GTCU has been operationalized through a self-report instrument. This instrument was initially designed to study the digital abilities of Canadian teachers (Desjardins, 2005; Desjardins et al., 2001). Over time, it developed to explore the digital competencies of professors and students at a Canadian, science and technology university (Desjardins & vanOostveen, 2015; Desjardins et al., 2010; DiGiuseppe et al., 2013). The current GTCU instrument collects three sets of data: 1) six socio-demographic items consisting of gender, age, occupational role and domain, highest level of education completed and educational specialization, 2) digital device (computer, cell phone or smartphone, tablet, gaming console, "wearable," and computer appliance) ownership, selected by levels of device connectivity and purpose of use (personal, work, studying or teaching), and 3) 26 categorized activity items (five for technical, and seven each for social, informational and epistemological) organized into six device-specific sub-items, each with two measures: frequency of use and confidence of use, considered as both individually significant and mutually interdependent indicators of digital competence.

Frequency of use is conceptualized as an important *general* indicator of competency on the assumption that transferable procedural knowledge, and in many cases, accompanying knowledge and higher-order abilities, are reinforced through purposeful use of digital devices (i.e., practice leads to acquired ability). Of course, frequency of use, an experience-related construct, is expected is expected to be a bit slippery as a predictor of performance in learning contexts. As van Deursen (2010) and Eshet (Eshet-Alkalai & Chajut, 2009, 2010; Soffer & Eshet-Alkalai, 2009) have found through extensive observational research, higher-order skills—for example, creative expression or epistemic thinking (Barzilai & Eshet-Alkalai, 2015)—often do not grow with years of technology experience, likely because they require the development of general intellectual abilities in addition to experience with specific forms of technology.

Confidence of use, a self-concept addressing one's capabilities to select and execute courses of action, is directly aligned with self-efficacy (Bandura, 1993; Bunz, 2004; Eastin & LaRose, 2000). As such, it is considered an important general predictor, not necessarily of acquired ability, but rather of an individual's willingness to pursue new activities, positively address challenges that occur, and extend abilities already acquired. In educational contexts, a learner's beliefs about their capabilities play an essential role in academic achievement (B. J. Zimmerman, 2000). In specific relation to digital-learning contexts, confidence relates weakly to simple skills such as copying files or performing basic searches for information. It relates more strongly to judgements of one's ability to apply such skills to more complex tasks problems.

As noted above, both frequency and confidence of use are measured in relation to specific devices (e.g., smartphone, tablet, laptop, etc.) because display and keyboard size, user-interface design, supported input modes and split attention (when using mobile devices while commuting, for example) are all conjectured to influence effective use. Mobile devices have become especially significant in defining sub-domains of digital-learning and readiness, owing largely to a steady growth in use. For example, average daily time spent on the Internet through a mobile device by individuals worldwide increased steadily from 2012 to 2015, from 74.4 minutes to 119.4 minutes per day (Statista, 2016), and it is estimated that over two-thirds of the world's population possess mobile access (Dabbagh et al., 2016). Recently, van Deursen (2015) and Litt (2013) emphasized the need for research to focus far more on mobile competencies owing to the strength of this global phenomenon. Indeed, a few educational researchers view mobile learning as a "fourth wave" (Pownell & Bailey, 2000), distinct from other forms of e-learning (T. H.

Brown & Mbati, 2015), although many adopt a discourse of continuity (Ozuorcun & Tabak, 2012).

In the end, by focusing on experience and confidence as twin indicators (addressing behavioural and attitudinal dimensions), and associating self-report items with specific types of devices, the GTCU instrument provides a depth of self-report data well beyond existing readiness instruments. However, gaps in our knowledge remain regarding how a learner's self-reported experience and confidence relate to successful performance in a context of digital learning. The formal research questions presented below, which guide the next portion of this inquiry, represent an effort to address a portion of these gaps.

2.4 Research Questions

1. *What model can be proposed to conceptualize the key dimensions of performance-activity design and serve as a basis for relating lab-based, digital-learning activity to self-reported experience and confidence?*

It is necessary to address this question first because, as will be shown, current digital competency research lacks consistency and offers little theorization regarding the elements of activity design for performance observation. When this question has been addressed through secondary research, the following questions will be address through primary, data-collection and analysis.

2. *Do self-reported GTCU competencies, focused on the twin indictors of frequency of activity and activity-related confidence, show positive correlations with performance quality in a context of digital-learning?*
3. *What "gaps" emerge between the self-report data and performances of individuals in specific activity contexts, and how can these gaps be explained? That is, what types of situational influences, not addressed by the GTCU, thwart successful performance?*
4. *Can the GTCU be used as an effective instrument for the initial probing of digital-learning readiness? Do meaningful patterns, related to general readiness, emerge between reported GTCU competency scores and assessed performance on authentic digital-learning activities?*

3 Modeling Performance Activity and Observation

Some existing research compares self-reported digital abilities to performance activity in a relatively direct manner (Bunz, 2004; Bunz, Curry, & Voon, 2007). For example, an individual is asked how well they can perform a specific procedural task (e.g., saving or renaming a file), and then this same individual is invited into a lab setting, offered a computer, and asked to perform this task without any reference to context or broader purpose. Such research may even adopt language like "perceived" versus "actual" to distinguish (and assign relative epistemological value) to self-reports, on the one hand, and performance data, on the other hand (Bunz et al., 2007; Hargittai & Shafer, 2006).

This study is not primarily concerned with direct comparison of individual claims regarding well-defined, technical tasks, and observed performance of these tasks. Rather, the conjectural perspective pursued by this researcher, developed through exploratory empirical activity, is that establishing a fair (and remedially useful) profile of individual readiness for digital learning requires consideration of broader patterns of correspondence between an individual's digital-competency perceptions and the quality of performance on "authentic" digital-learning activities. Readiness, in this sense, relates not only to an individual's ability to perform acquired digital skills, but also the ability to: (a) demonstrate proficiency across several dimensions of interaction; (b) effectively align digital affordances with objectives; (c) learn new procedures on-the-fly, using Internet-accessible resources; (d) transfer skills acquired from one device and environment, to other devices and environments; (e) identify, solve or effectively work around technical glitches with calm and considered perseverance; and (f) offer creative/divergent solutions to problems—all in the service of deep and meaningful learning (i.e., beyond repetition of behaviours and rote memorization).

The challenge is to implement a research design that effectively facilitates/instigates these often-interdependent phenomena.

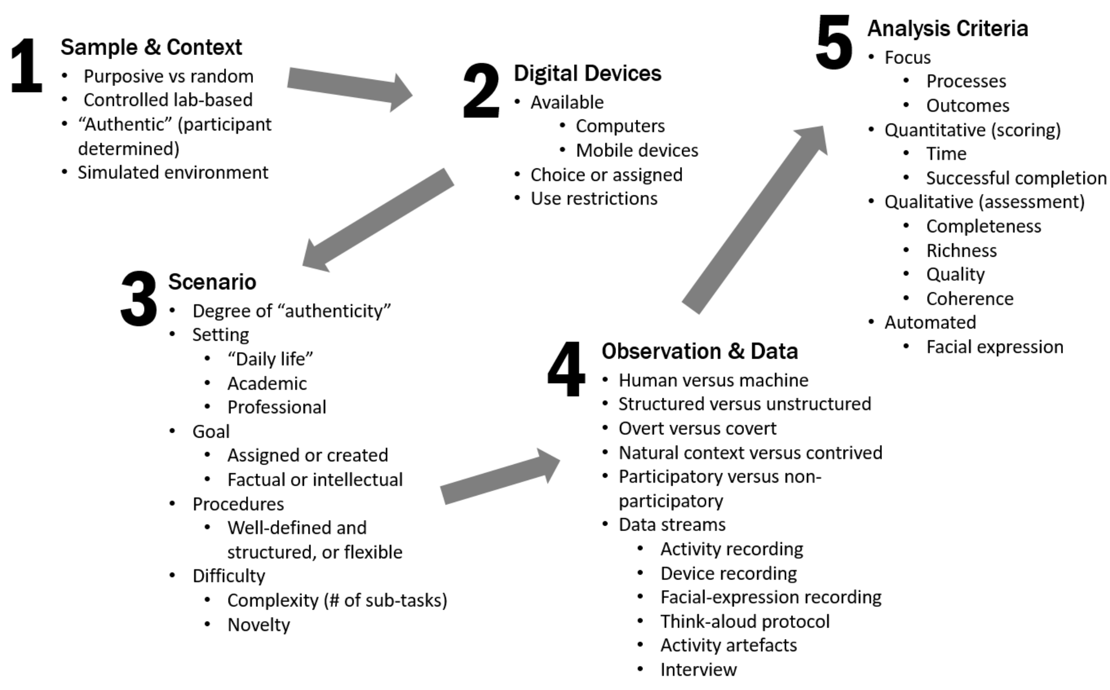
3.1 Designing Performance Activities and Observations

Researchers make numerous influential, and sometimes unstated, research-design choices to observe performances of human-computer interaction. By reviewing the performance-analysis methodologies of digital-competency research teams—drawn from those listed above (p. 18-19), and incorporating insights from Human-Computer Interaction (HCI) research—a five-dimensional, generic model is constructed, as presented in Figure 3. These dimensions address: (a) the sample and context of performance (considered together because in ethnographic studies the sample can determine the context); (b) the specific computer devices and software environments used or made available for use; (c) performance activity type—one of the most important and potentially complex dimensions influencing, above all, a participants activity-related motivation; (d) observational characteristics and selected data streams of interest; and (e) analysis criteria. This generic model offers a basic framework for conceptualizing and organizing the activity designs and research methodologies used by other researchers.

Importantly, this model highlights the degree to which researchers shape the nature of performance. From a constructivist perspective, it suggests that a sharp distinction between "perceived" and "actual" in relation to digital-competency performance research breaks down amidst a tangled web of purposeful, research-design choices. Indeed, when researchers (such as this one) choose to abandon objectivist notions of performance as a gold standard, attention shifts to triangulating multiple data streams so as to arrive at a contextually rich portrayal of digital competency. The degree to which this portrayal is generalizable will remain an important question to be addressed in relation to purposes and goals, of learners and researchers, in each context of inquiry.

Below, each dimension is briefly reviewed with special reference to digital-competency observational research.

Figure 3. Generic Performance Observation Design Model



3.1.1 Sample and context

The first dimension relates to sample and context. With respect to sample, observational measurement research can most often be divided into two groups. The first recruits random samples of the general population (Hargittai & Shafer, 2006; Van Deursen & Van Dijk, 2010), and the second, purposive samples of students and college graduates (Eshet-Alkalai & Amichai-Hamburger, 2004). Because the literature demonstrates a positive relationships between educational level, and both digital skills and positive attitudes towards the use of digital technologies (Litt, 2013), one might expect the performance of university students and graduates to skew towards more advanced functioning. Owing to the resource intensiveness of performance observation, 100 participants for a single wave of observation represents a considerable sample size achieved by only a few researchers (Hargittai & Shafer, 2006; Van Deursen & Van Dijk, 2010).

With respect to context, most observational studies are performed in a laboratory or similarly controlled academic setting (e.g., a university office setting). However, some have pursued creative approaches to observing authentic performance in less controlled settings. For example, Asselin and Moayeri (2010) leveraged TechSmith Morae*,* a usability software application, to capture the screen activity and related thoughts (via a think-aloud protocol) of participants engaged in homework activity on personal computers within their homes. As one might expect, this exploratory procedure raised several ethical issues related to privacy and the collection of "incidental" data (Asselin & Moayeri, 2010).

With respect to mobile devices, the most appropriate context for performance observation became a significant question in HCI research (Sun & May, 2013). The dominant understanding was that human-mobile interaction needed to be studied in an "authentic" context of mobile use. This implied doing field research in public settings or on buses where individuals are both physically mobile and presented with competing environmental stimuli. Esbjörnsson et al. (2006), for example, argued that traditional laboratory settings do not adequately simulate the context where mobile devices are typically used, and therefore, data collected in laboratory observations may suffer from very poor levels of ecological validity. Kjeldskov & Skov's (2014), however, argue that both lab and field-based studies can serve important research purposes. Indeed, today, the use of mobile devices appear to be extending to all kinds of settings. Some lab-based researchers incorporate simulated environmental variables related to movement and divided attention while maintaining research efficiency and a controllable level of data quality (Sun & May, 2013).

3.1.2 Computer devices

The second dimension of the generic model addresses the type of computer device used by research participants to demonstrate their digital competencies. Surprisingly, some performance observation studies do not report what computer devices were used for participant activity (e.g., Eshet-Alkalai & Amichai-Hamburger, 2004; Greene, Seung, & Copeland, 2014). When reported, the tendency has been to use a PC and/or Mac desktop computer (Hargittai & Shafer, 2006; Van Deursen & Van Dijk, 2010). In light of this tendency, Litt (2013) called for more diversity in measurement practices to account, in particular, for the increasing popularity of mobile devices—a call more recently echoed by Park (2015). However, despite the appearance of mobile-based competencies in self-report instruments (Van Deursen et al., 2015), and small-sample studies (Jayroe & Wolfram, 2012), there are few signs that larger scale, observation research, like that carried out with desktop computers (Hargittai & Shafer, 2006; Van Deursen & Van Diepen, 2013; Van Deursen & Van Dijk, 2010; Van Deursen & Van Dijk, 2011b; Van Deursen & Van Dijk, 2015), is shifting to mobile devices.

3.1.3 Performance activity

The third dimension, and perhaps the most influential aspect of the model, relates specifically to the kinds of activities provided to research participants to demonstrate their digital competencies. In her synthesis of digital-skills measurement research, Litt (2013) emphasizes "high validity" and "robust accounts of human behaviour" as the key provisions of observational research. Yet, explicit discussion of the activity-design strategies serving observational research is absent—even though considerable variation exists, and key activity characteristics (e.g., level of perceived difficulty) may influence performance quality.

Conducting observations in the Netherlands with focus on functional access and digital inclusion, Van Deursen and Van Dijk (2010) design "fact-based tasks" that have a specific correct action or answer. "Open-ended tasks were avoided because of the ambiguity of interpretation of the many potential answers" (Van Deursen & Van Dijk, 2010, p. 901). Conducting observations in Israel with a greater focus on higher-order thinking activities, Eshet-Alkalai and Amichai-Hamburger (2004) designed their observations using "real-life tasks." These activities adopt the characteristics of "authentic tasks," as defined by Herrington (2006), including: (a) strong alignment with professional practice; (b) high complexity with ill-defined procedures open to multiple interpretations; (c) a flexible timeline for completion; (d) opportunity to reflect and consider different perspectives; (e) cross-disciplinary relevance; and (f) allow competing solutions with a preference for products that are valuable in their own right. In short, the observations of the Dutch and Israeli research groups are conducted through very different sets of lenses, founded on different approaches to effective use of technology.

The Information Science literature related to Web searching offer some complex and multi-dimensional models of activity design. For example, Li (2009) provides an activity classification model consisting of eight dimensions (source of task, task doer, time, product, process, goal, task characteristics, and user's perception of task), 13 sub-dimensions (e.g., goal quality and goal quantity), and 51 values (e.g., specific goal quality, amorphous goal quality, mixed goal quality) with operational definitions (e.g., "a task with explicit or concrete goals," "a task with abstract goals," "a task with both concrete and abstract goals"). Ding and Ma (2013), achieve a simpler framework by reducing this model to three facets considered most significant in relation to the observational study of online-searching competency (a sub-domain of information competency): (a) structure (well-defined or ill-defined), (b) goal type (factual or intellectual), and (c) topic or context (academic task or daily life task).

Ding and Ma (2013) provide a useful interpretive apparatus for digital-competency research. For example, major differences between the performance observation designs of Van Deursen and Van Dijk, on the one hand, and Eshet-Alkalai and Amichai-Hamburger, on the other hand, can be explained as relating to all three dimensions: degree of activity structure, the types of goals driving performance tasks, and the general life setting or context of use. Ding and Ma also offer conceptual convergence with the Problem-based Learning (PBL) framework of Savin-Baden (2000), which proposes five activity orientations similarly focused on the level of structure, nature of goals, and overall flexibility in the learning environment (i.e., context).

3.1.4 Observer interaction and data collection streams

The fourth dimension of the generic, performance design model addresses the role of the research observer and the selection of data streams. Boote and Matthews (1999) provide an apparatus for conceptualizing research choices related to the first aspect: role of the observer in relation to who and what is being observed. Their five classifications of observational research address several important research decisions shaping observation:

1. Human versus machine observation.
2. Structured versus unstructured observation.
3. Overt versus covert observation.
4. Natural versus contrived observation.
5. Participatory versus non-participatory observation.

The first classification is relevant to today's digital observational facilities in which audio-video capture devices may replace the researcher as the "observer" of live activity. The second classification, relating to the structure of the observation, overlaps with the structure of the activity being observed. Where the researcher has defined the structure of the activity, the structure of the observation will generally follow. The third classification, referring the degree to which the observer is perceived by the participant as being present, can influence the level of participant anxiety and motivation. The fourth classification, is somewhat controversial. The degree to which a lab-based observation can be considered "natural" would relate not only to the physical environment, but also to the authenticity of the activity and the sense of immersion experienced by those being observed. Finally, the fifth classification overlaps somewhat with the third, and relates to the degree the researcher writes herself into the scene.

Shifting attention from observer, and returning to the concept of "machine observation," digital-recording technologies are increasingly used in observational studies to capture audio-video data of activity, often from multiple simultaneous perspectives (Bhatt & de Roock, 2014; Knoblauch, 2012), or to capture (and sometimes machine-analyse) multiple additional streams of data (e.g., spoken thoughts, facial expressions, physiological responses, eye-focus and movement, etc.) in real time. In fact, multi-stream, digital recording of human-computer interactions using a variety of computing devices, cameras, sensors and automated analysis applications has only begun to impact the domain of digital-abilities observational research (Bhatt & de Roock, 2014). The effects of these developments can, on the one hand, cause a distancing of human researchers from live activity—especially in contexts where they are called upon to function as a technologist responsible for achieving high-fidelity recording of activity. On the other hand, audio-video recordings can provide the researcher with incredible amounts of data, capable of being reviewed backward and forwards numerous times at any speed, giving access to a significant, and sometimes overwhelming, depth of sight and sound.

In relation to observer interactions and data-collection streams, digital-competency research pursues a variety of options. Hargittai (2002), and Hargittai and Shafer (2006) employ a mix of human and machine observation. The selected data streams of interest are screen activity and spoken participant thoughts ("speak aloud protocol"), both captured by system recording software running on the designated participant desktop. The observation is semi-structured, including segmented activities but no specific time limits. Hargittai interacts with participants based on their articulated thoughts and perceived levels of enthusiasm and/or frustration. Her observational positioning is overt. (She is seated right behind the participant stationed at a desktop computer.) She functions in an observer-participant role. She converses with the research participant, responds to key events, provides encouragement and moves the observation to the next task at a time deemed appropriate (e.g., when a task has been completed, or when it appears the participant is experiencing significant frustration).

Van Deursen and van Dijk (2010) largely follow the observer interaction and data-collection methodology of Hargittai—with a few exceptions. They do not report the use of any screen recording software or other video capture devices. Rather, "the experimenter directly measured the assignment completion and time needed" (Van Deursen & Van Dijk, 2010, p. 900). With no focus on user perceptions and motivations, they directly engage the user far less during performance, interacting only to move the observation to the next task when a prescribed time limit had elapsed. In the end, they adopt an observational repertoire characterized by higher structure (time limits) and lower participation (interacting only to administrate tasks) than Hargittai.

Eshet-Alkalai and Amichai-Hamburger (2004) focus on human observation (analysis) of prescribed task outcomes rather than processes. They use a variety of desktop software applications to facilitate activities, but, like van Deursen and van Dijk, no processes are machine-recorded. Rather, the products of activity are stored for post-performance evaluation. The evaluation process is structured by qualitative criteria defined in a rubric. In this way, aside from assigning the tasks, the researchers remain absent from activity performance, and become present only to collect the results.

3.1.5 Analysis methodology

The final dimension relates to analysis criteria and analysis methodology. First, analysis of an activity can be process-focused, outcome-focused, or mixed. Second, it can be timed and scored, judged or mixed. Finally, it may involve immediate analysis, or delayed analysis of recorded data streams that may include text (e.g., transcribed audio), audio-video files, and/or numeric data.

Despite creating digital recordings of screen activity and the expressed thoughts of participants during activity, Hargittai and Shafer (2006) focus their analysis on task completion without consideration of time. (Participants were able to take as long as they wanted to perform each task.) Thus, they report task-success rated by order of perceived difficulty and percentage of tasks completed successfully. Task difficulty was established through analysis of expressed perceptions of participants gathered via a think-aloud protocol, and through discussions with participants during and after the performance activity.

Concerned about efficient use of digital technologies, Van Deursen and Van Dijk (2010) scored all participants on both successful completion and time required. Consequently, they report average percent of tasks completed and average time spent on tasks. These two metrics form the basis of skill measurement in their research. However, elsewhere Van Deursen and Van Dijk report a variety of common “error” types noted during observations (Van Dijk & Van Deursen, 2014). Therefore, although quantitative data takes centre stage, some qualitative data (i.e., descriptions of user-interaction errors, defined by the researcher) was considered for secondary reporting.

Eshet-Alkalai and Amichai-Hamburger (2004), focusing on the digital outcomes of authentic task performance, constructed a rubric with sets of qualitative assessment guidelines specific to each categorized activity. For example, the photo-visual activity, involving the creation of a theatre stage using a multimedia application was assessed in relation to qualities of completeness, number of elements and complexity. The information-literacy activity, which focused on an analysis of a news event presented by multiple international media sources, was assessed by the number of biased statements identified, and an estimation of the participant's ability to analyse a story critically. The validity of this methodology was established through inter-rater reliability procedures, demonstrating high coherence.

Importantly, none of these domain-leading researchers performed analysis of audio-visual or other forms of digitally recorded data. However, some others have explored a variety of technical setups for doing so (Asselin & Moayeri, 2010).

3.1.6 Towards a research design

Exploring the five dimensions of choices and the specific performance observation methodologies implemented by key digital-abilities research teams, as described above, provide a conceptual foundation for the following research design. As previously noted, prior to this investigation, there were no established procedures for relating self-reported GTCU data to individual activity because the instrument originated largely through theorization and expert consultation rather than formal, performance observation.

4 Method

Having developed a conceptual framework for performance observation through a literature analysis, specific procedures and technology configurations for addressing the research questions (2-4) were refined through iterative techno-methodological exploration of EILAB data-collection affordances, and a pilot study involving seven participants. A full presentation of the pilot study is beyond the scope of this thesis. However, a few details about survey implementation, activity design, and relating reported competencies to performance activity, are provided below in order to highlight lessons learned and modifications made as a result.

4.1 Preliminary Techno-methodological Exploration

4.1.1 EILAB affordance testing

The EILAB is the digital observatory and international collaboration facility providing the observational and performance-activity context for this study. This facility consists of an activity room and an adjacent, glassed-in observation room, housing a variety of both fixed and mobile digital affordances. The activity room offers several large-screen displays, six high-definition (HD), remotely controllable (PTZ) cameras (four mounted on the ceiling and two mobile units), and variety of audio-capture affordances, all served by a gigabit local area network (LAN), and a university network with high-bandwidth connectivity to the Internet. The observation room houses a well-equipped, workstation-level computer with two 4K screens (optimized for camera control and audio-video recording), a sound board, and a variety of camera-control input devices. Non-obtrusive, visual access to the entire activity space is made possible through large glass windows covered with a translucent mask.

The EILAB maintains a variety of computers and mobile devices for participant observations, in several form factors and from a variety of vendors, including Apple and Samsung. Key software assets include the Noldus scientific software suite, featuring: (a) Media Recorder 4 for supporting multi-perspective, synchronized recording using up to four HD cameras and audio sources; (b) FaceReader 7, for conducting automated, machine-analysis of participants' facial expressions; and (c) The Observer XT 13, for synchronized coding and analysis ("observation") of the recorded data streams. (The researcher had prepared the lab setting to produce a machine-generated, statistical dataset of emotional responses using FaceReader. However, owing to the complexity of the methodology, and the need to constrain the scope of this study, it was decided—subsequent to the time of writing—that this data would be generated at a later date for a secondary study.)

Many hours were logged exploring and optimizing, physical and technical, configurations for capturing multi-perspective, audio-video recordings of real-time, human-device interaction in the EILAB environment. This included addressing several variables such as camera angles, resolution and mounting options, software configurations, environmental lighting, device positioning, participant positioning, adapting to numerous physical attributes (height, hairs styles, etc.), screen-capture options, quality of audio-video output, and data management and storage. Having achieved an initial set of configurations that produced good levels of data-capture stability and recording quality, a pilot study was launched.

4.1.2 Pilot study

The pilot activities were designed by balancing two priorities: (a) facilitating direct comparisons between performance tasks and self-reported competencies; and (b) providing authentic scenarios that supported a degree of autonomy, and therefore, nurtured participant motivation (Deci & Ryan, 2000). To capture digital-competency reports, three short versions of the GTCU survey instrument were used, with each version focused on a specific dimension of interaction (epistemological, social or informational). To facilitate a variety of performance activities aligned with reported competencies, nine scenarios were designed, each with a three-task structure. Each scenario, focused on a single GTCU dimension of interaction, was coupled with its corresponding survey instrument to create a single activity and performance module. The scenario activity was goal-based and incorporated intellectual tasks, requiring participants to summarize, distinguish, pursue a new idea, make a decision, or solve a problem without the possibility of a single correct response (Li, 2009). Flexible procedures were expected to facilitate richer demonstrations of knowledge, skills and attitudes than highly defined ones. Therefore, the scenarios designed for pilot testing plotted a middle ground between the well-defined activities implemented by van Deursen and van Dijk (2010; 2014), and the creative activities designed by Eshet (2012). In terms of process, participants visited the lab to complete their randomly assigned module using one of the provided mobile devices. This activity was captured from three perspectives, which included the participants face, a top-down view, and a screen capture of the device, using three ceiling-mounted cameras.

4.1.3 Key changes to methodology based on pilot study

After seven participant observations, the procedures, overall functioning of the technological affordances and collected data were analysed. On these bases, several methodological changes were defined, proposed, and approved by the thesis supervisor and UOIT’s Research Ethics Board (Appendix L). These related to activity design, the implementation of the self-report instrument, overall quality of recorded data, and data triangulation. The most significant changes were as follows:

- *Number of activities were reduced*. The number of activities were reduced from nine to three owing to the challenges in attracting research participants and the consequent small sample sizes. It was recognized that fewer activities performed by more participants would allow patterns of activity to emerge.
- *Task complexity and dimensionality of activities were increased*. The pilot activities, which offered scenarios focused on basic skills aligned with specific GTCU dimensions posed little challenge to most participants (students and educators recruited from UOIT and Durham College) and their single dimensionality gave them an artificial character. In several cases, activities were completed in under 15 minutes with participants displaying few signs of being challenged (e.g., taking time to think and develop a completion strategy, exhibiting gestures and expressions of concentration, pausing to review the activity description, using Google or YouTube to solve a procedural problem, searching for an appropriate affordance, etc.). Based on this experience, the scenarios were redesigned to simulate multidimensional research experiences. It was conjectured that increasing complexity and dimensionality would heighten the perceived level of challenge, improve levels of performance motivation, allow greater opportunities for performance differences to emerge, and facilitate a more authentic digital-learning experience.
- *Task activities were more strongly aligned with GTCU indicators***.** In order to facilitate closer comparison between self-reported activity and performance activity, the task descriptions were more strongly aligned with specific GTCU items, and coded as such. At the same time, effort was made to "stay true" to the scenario and ensure the overall activity would be perceived as authentic. The goal was to integrate GTCU items into tasks that blended together to form an authentic scenario.
- *A single, longer version of GTCU self-report instrument was deployed***.** In parallel with increasing task dimensionality, the dimensionality of the self-report instrument was also increased. More specifically, a single instrument was deployed representing the full set of GTCU activity indicators, from three orders of activity (social, informational and epistemological), and three categories of devices (computer desktops/laptops, smartphones and tablets).
- *The quality of digital, video recording was improved***.** Two, new HD (1080P) PTZ tripod-mountable AXIS cameras were purchased by the EILAB, and deployed in place of older, standard-definition and less flexible (ceiling mounted) units. This hardware upgrade significantly increased what could be seen during analysis. In fact, screen

mirroring of mobile devices, which introduced a number of technical challenges during observations, proved redundant with one of the new cameras mounted on a tripod, and positioned over the shoulder of a participant. Owing to the increased resolution and maneuverability, this camera clearly showed hand-device interactions *and* a fully readable screen—the single exception being a few high-contrast menus on a Samsung tablet. Similarly, by using the second camera to capture the participant's facial expressions, and making improvements to how the participant and device were positioned in relation to this camera, our ability to conduct both human and machine, post-activity analysis of facial expressions/emotional responses were significantly improved.

- *An optional speak-aloud protocol and post-activity semi-structured interview were introduced to increase data richness.* Owing to under-utilization of a high-fidelity, ambient microphone and sound separation system during the pilot project, and the desire to increase the richness of the data, an optional speak-aloud protocol and post-activity interview were introduced. The interview focused on capturing perceptions of activity difficulty, experiences of comfort and anxiety, and promoting (and capturing) self-reflection on participant's perceived general readiness to engage in fully online learning, particularly in relation to using a tablet.

4.2 Research Design

Having learned these lessons through pilot observations, the final research design is presented below. Data was collected using a self-report instrument, multi-perspective, audio-visual recording of performance activity, post-activity interviews and field notes.

4.2.1 Self-report instrument

The GTCU survey tool adopted for this study was implemented on Survey Monkey (http://www.surveymonkey.net), an online-survey application provider. (A full PDF version, including letter of consent, is provided for reference in Appendix B). The instrument, as adapted for this study, includes four socio-demographic items, two device access/ownership items and 26 categorized (Informational, Social and Epistemological) activity items organized into three device-specific sub-items (computer desktops/laptops, smartphones, and tablets), each with two measures—frequency of use and confidence of use. Frequency of use is measured using a 5-point Likert scale: *never, a few times a year, a few times a month, a few times a week, daily*. Confidence of use is also measured using a 5-point Likert scale: *do not know how to use; not confident, require assistance to use; confident can solve some problems; fairly confident, can use with no assistance; very confident, can teach others how to use*. Gaming devices, internet appliances, and wearable digital technologies, which appear on the official GTCU profile tool, were removed for purposes of this study. A complete list of items is provided in Appendix D.

4.2.2 Performance activities

Three scenarios, summarized in Table 1, were designed to incorporate multidimensional human-computer interactions, provide a significant degree of challenge, and adopt the characteristics of an authentic activity, as defined by Herrington's (2006) guideline. This guideline states that an activity is authentic if meets at least of six of the 10 criteria, as paraphrased below. (The seven items in italics represent those criteria used to design the scenarios used in this study, as presented in Appendix E. Items 8-10 were not incorporated given the context of activity and related time constraints.)

1. *Relevance to what academics/professionals do in practice in the real world.*
2. *Offers a degree of structural openness.*
3. *Provision for opportunities to reflect.*
4. *Allowance for creativity and perspectival differences.*
5. *Relevance to multiple disciplines or academic domains.*
6. *Assessment consistent with criteria used in the real world.*
7. *Acceptance of different solutions and diversity of outcomes.*
8. Extended periods of activity time (days weeks and months)
9. Opportunities for collaboration.
10. Development of a "polished product," useful in its own right.

Each of the three scenarios was organized around six goal-driven tasks, with each task mapped to a specific GTCU self-report item. For example, Scenario 1, Task 1, asked the participant to find a journal article on a research topic of interest using a date-related inclusion criterion. This task was mapped to the GTCU Item 16 in the self-report instrument (see Appendix D for numbered and ranked lists of survey items), which measured an individual's experience and confidence related to searching and accessing journal or news articles online.

Significant effort was made to align tasks with survey items to facilitate meaningful comparison between what was reported and performed. At the same time, there was sometimes a trade-off between maintaining the integrity of a scenario as an authentic activity and achieving direct correspondence with a particular item. In the end, some tasks mapped more directly, on a conceptual level, than others. An example of a task that mapped less directly is Scenario 2, Task 2, which asked the participant to select and extract data from an online database. This task is mapped to GTCU Item 25, which related very generally to "sorting large amounts of data." Yet, on the whole, a balance has been achieved between mapping constituent tasks to survey items, and maintaining the flow and authenticity of a scenario.

To situate these scenarios in relation to the activity-design model, the nature of task goals, structure of the procedures and novelty/complexity of the tasks were considered. The scenario and task goals, which incorporated different degrees of intellectual activity (none were strictly fact-based), were controlled by the researcher to facilitate meaningful correspondence to self-report items. The procedures, however, offered some flexibility. In fact, few task descriptions provided specific procedures for completing a task. Moreover, the specific choice of software affordance to accomplish a defined goal was often left entirely to the participant. When an application, such as Google Drive, was specified by the task to facilitate ease of access for both the participant and researcher (who located and collected scenario artefacts), numerous other procedural choices, related to access and use, remained open. For example, Google Drive could be accessed with a dedicated application or in one of the several installed browsers; and, there are numerous options for saving files to a folder. Finally, with respect to complexity and task novelty, considerable effort was made to create tasks that would provide a significant level of challenge, and facilitate flow (Nakamura & Csikszentmihalyi, 2002).

Table 2: Authentic Performance Scenario Summaries and Item Mappings

Scenario Title	Premise	GTCU Item Mappings
1: Presentation Preparation	Reflecting on a research topic from your own educational experience, this six-step activity asks you to prepare and share materials for a fictitious presentation (for a general academic audience).	I16, I17, E22, E23, S12, **S11**
2: Democracy Data Analysis	The World Values Survey (WVS) is a global network of social scientists studying changing values and their impact on social and political life. In preparation for a symposium on education and democracy, this six-step activity asks you to select and manipulate data, and share this data with a collaborator via text messaging and email.	I15, E25, *S13*, E26, S8, **S11**
3: Conceptual Model Drawing	The Community of Inquiry (CoI) framework is a model of collaborative learning. The Fully Online Learning Community (FOLC) is another model derived from the CoI. One difference between these models is that CoI consists of three dimensions (Social, Cognitive and Teaching Presence), but FOLC consists of two dimensions (Social and Cognitive Presence) situated within a fully "digital space." This six-step activity involves the development and sharing of conceptual materials for a FOLC research project.	*S13*, I18, E24, I20, S14, **S11**

In the end, the three performance scenarios, as summarized in Table 2 and detailed in Appendix E, were designed and implemented. Scenario 1 related to the preparation and development of materials for an academic presentation. The six constituent tasks incorporated an even mix of two informational, two epistemological and two social tasks (as defined by the GTCU framework). Scenario 2, asked the participant, as part of a fictitious research team preparing for an upcoming symposium, to prepare a data-set and interact with a fellow contributor. This scenario incorporated one informational, two epistemological and three social tasks. Finally, Scenario 3, challenged the participant to prepare a visual representation of a new conceptual model, derived from an existing model. This scenario consisted of three informational, one epistemological and two social tasks.

Taken together, these scenarios incorporated 15 distinct GTCU self-report items from the 21 total items of the social, informational and epistemological orders. The five GTCU technical items were excluded from consideration, owing to their conceptual overlap with the other dimensions, and their indirect nature. All scenarios shared one common social item (S11: communicating via email). A second social item (S13: using an online collaboration or file sharing platform) was shared between Scenario 2 and 3 only. This minimal repetition of items was required to maintain scenario authenticity and facilitate collection of performance artefacts.

4.2.3 Post-activity interview script

As shown in Appendix H, five questions were prepared to guide the semi-structured, post-activity interviews. These focused on participant's perceptions of scenario difficulty, levels of comfort/confidence while performing constituent tasks of the defined scenario, and overall readiness to engage in fully-online learning in a context of higher education using a tablet device. Gaining participant feedback regarding scenario difficulty, provided a vital piece of data with which to assess each scenario's level of challenge. Asking each participant to self-evaluate their level of readiness (after completing the survey and performance activity, which provided an interpretive context for reflection), offered another vital data-point with which to triangulate the findings.

After responding to the prepared questions, participants were encouraged to discuss their research-participation experience, and broader history of using digital technologies inside and outside formal learning contexts. In several cases, these casual conversations provided insights into the lives of participants, and expanded the hermeneutical context for performance analyses.

4.2.4 Field notes

During the recording of performance activities and post-activity interviews, notes were maintained by this researcher. These were checked against the recordings and included in Appendix I.

4.2.5 GTCU Profile Tool baseline data

Selected baseline statistics (e.g., activity item averages) were calculated from the entire GTCU database of almost 700 individual surveys (at the time of writing), which had been collected from several educational institutions via the online GTCU Profile Tool (http://gtcu.eilab.ca). This data allowed the researcher to report the relative strength of the digital competencies reported by the participants of this study, and infer such things as the expected difficulty of specific performance tasks. This technique of using the entire GTCU database to calculate baseline statistics and position a sample will become more significant as the database expands to include a broader representation of individuals surveys drawn from a greater diversity of locales and institutional contexts.

4.2.6 Participants

Readiness for digital learning in higher education at the micro-level relates mainly to human participants, of which students and teachers are the most significant actors. Following approval from UOIT's Research Ethics Board (#13-082, as provided in Appendix L) participants were recruited from the student population at University of Ontario of Technology (UOIT), Oshawa, Canada—a mid-size technology-oriented university, where the researcher and the EILAB facility are located—through an email recruitment process that followed the university's guidelines.

Owing to a low response rate, efforts were made to improve the recruitment process. A draw prize of an Apple tablet was introduced after receiving REB approval (Appendix L). A target sample size was set at 30 (10 participants per activity) following a widely accepted rule-of-thumb in qualitative research related to expected saturation points (Mason, 2010). However, owing to an aggressive time frame for data collection and ongoing recruitment challenges, the researcher adopted 15 as the minimum acceptable sample for achieving saturation following the more pragmatic guideline of Bertaux (1981).

Importantly, after the project received support from a professor associated with the EILAB, 13 individuals contacted the researcher to participate. Two spots were filled through email recruitment. Participants were randomly assigned to one of three scenario groups. Owing to a scheduling error, equal distribution of participants was compromised. Therefore, Scenario 1 was performed by six participants, Scenario 2 by four, and Scenario 3 by five. A full summary of the participants is presented below in Table 3 (p. 41).

This sample was 73% female, consisting primarily of undergraduate students, with one recent graduate, one current graduate student and one post-doctoral, visiting scholar. The average age was 29, with nine in their 20s, two in their 30s, three in their 40s, and one participant over 50. Most were studying education, with two indicating a science specialty, and two an economics/commerce specialty. Importantly, most (80%) owned or regularly used a laptop computer, smartphone and tablet. Only two participants did not use a tablet regularly, and only one used neither a tablet nor smartphone regularly.

Table 3: Participants Grouped by Activity

	Participant	Gender	Age	Educ. Level	Domain	Devices Used	Principal Use
Activity 1	P1	Male	40	Bachelors	Education	Laptop Smartphone Tablet	Study Social **Social**
	P3	Male	26	Bachelors	Education	Laptop Smartphone Tablet	Study Social **Study**
	P6	Female	23	Graduate	Education	Laptop Smartphone Tablet	Study Social **Entertainment**
	P8	Female	34	Bachelors	Education	Laptop Smartphone Tablet	Social Creative **Study**
	P12	Female	24	Bachelors	Education	Laptop Smartphone Tablet	Work Entertainment **Entertainment**
	P13	Female	46	Bachelors	Education	Laptop Smartphone Tablet	Study Social **Entertainment**
Activity 2	P2	Female	24	Bachelors	Education	Laptop Smartphone Tablet	Study Social **Entertainment**
	P4	Male	41	Bachelors	Education	Laptop	Study
	P5	Female	22	Bachelors	Biology/Educ.	Laptop Smartphone Tablet	Work Entertainment **(Not reported)**
	P10	Female	22	Bachelors	Science/Educ.	Laptop Smartphone	Study Other
Activity 3	P7	Female	23	Bachelors	Education	Laptop Smartphone Tablet	Study Social **Teaching**
	P9	Male	22	Bachelors	Education	Laptop Smartphone	Study Work
	P11	Female	30	Bachelors	Education	Laptop Smartphone Tablet	Study Entertainment **Entertainment**
	P14	Female	22	Bachelors (Graduated)	Commerce	Laptop Smartphone Tablet	Entertainment Work **Entertainment**
	P15	Female	51	Post-Doctoral	Economics	Laptop Smartphone Tablet	Work Social **Entertainment**

Participants were asked to categorize their principle use of each device owned or used regularly with one of the following seven descriptors: work, study, teaching, creative, entertainment, social or other. This list extended the standard GTCU set, which included only work, study, teaching and personal. Additional purposes of use were included following the lead of researchers who are extending digital competency research to include consideration of human purposes and tangible outcomes driving technology use (Blank & Groselj, 2014; Brandtzæg, 2010; Helsper et al., 2015; Van Deursen & Van Dijk, 2014).

During an early phase of analysis, it was noted that the methodological decision to extend the purpose-of-use items was enriching the data set. Of the 12 participants reporting ownership or regular use of a tablet, seven reported their primary use as entertainment. This is consistent with the manner in which tablets have historically been marketed, and by including it as an item, we were able to note that the five reporting more "serious" uses of a tablet differed from the majority of participants in this study, and the currently expected norm.

4.3 Sequenced Data-Collection Procedures

The procedures described below were conducted between October 2016 and March 2017 primarily at the EILAB, UOIT, Canada. Only the survey data were collected online outside of this physical setting.

4.3.1 Initial lab setup

Prior to the commencement of activity-recording sessions, a physical and technical setup was implemented in the EILAB. As shown in Figure 4 below (p. 43), an activity area was selected based on lighting quality, and within this area, computers selected to be part of the study, were installed, updated, and checked. An activity station was arranged consisting of: (a) a table and a non-swivel chair; (b) a mobile device holder, constructed by the researcher to keep the device in a fixed position on the table, in landscape orientation, and at a strategic height; (c) two tri-pod mounted cameras, one positioned to capture the device screen and hand-device interaction over the shoulder of the participant, and a front-facing camera positioned to capture the participant's face over the device stand; (d) a computer with a large-screen display positioned in front of the participant table, above the front-facing camera, presenting the activity description in position requiring only a slight upward tilting of the head; (e) a portable router, to service both cameras, and various cables managed as tidily as possible. Although there was initial concern that the amount of cabling and computer equipment surrounding the participant might undue anxiety, the opposite reaction was often observed. When the researcher apologized for "all the wires," several participants expressed enjoyment at the amount of visible technology, suggesting it demonstrated that this was a "serious study."

Prior to participant scheduling, and with the physical setup complete, the three activity descriptions were uploaded to secure web pages for on-screen presentation, and randomly assigned to activity sessions.

Figure 4. Performance Activity Setup in EILAB

4.3.2 Data collection

Upon receiving a participant confirmation email, a custom data-collection link to the online survey (coded to the participant's assigned number) was delivered with a request to complete the survey *before* visiting the EILAB. A one-hour observation was then scheduled at a mutually convenient time. Twenty-four hours in advance of an observation, as part of routine preparation, the researcher checked SurveyMonkey to ensure the survey had been fully completed. In three cases, participants completing the survey on a smartphone, inadvertently missed a set of items. These were completed quickly, prior to the scheduled observation, after the researcher notified the participant of the issue.

An hour prior to an observation session, the researcher powered up and ran basic diagnostics on the supporting technologies, including cameras, computers, mobile devices. Video and sound checks were also performed. The activity station was prepared by ensuring the mobile devices (an iPad Air and a Samsung Tab 2), were switched on, logged into the appropriate Wi-Fi network, updated, and positioned on the activity table. The activity title was presented in a web browser on a large-screen display. The activity description itself was hidden from view so that a participant's initial reaction to the assigned activity could be captured as recorded data. Finally, the online survey instrument was checked to ensure that a full set of responses had been received prior to a participant's arrival.

Upon arrival, the participant was welcomed to the facility, given a brief tour (to encourage comfort with the environment) and asked to sit at the activity table. Next, the participant selected the tablet device with which they were most comfortable. The selected device was positioned in the stand, and set to the home screen. The researcher then read a prepared script (Appendix C), which addressed: (a) the nature of the activity; (b) start and stop procedures; (c) guidelines related to acceptable use of the device; (d) the optional think-aloud protocol; (e) researcher inaccessibility during the activity except in the cases of technical failure; (f) body- and device-positioning constraints; (h) the 50-minute, general time constraint for the completing the activity; (i) the post-activity discussion to be held upon completion; and (h) any questions. Once questions were answered and the participant assumed a comfortable working position, the researcher left the activity room, and entered the glassed-in observation booth to perform final camera calibrations, start the digital recording, and signal the participant to start.

During the activity, the researcher primarily monitored the technology affordances to ensure recording quality, and address technical issues as quickly as possible. (Only a few times over the course of 15 participant sessions was an activity interrupted to address an issue. For example, in one instance the iPad was incompatible with a web site function, and it was quickly swapped out for the Samsung tablet.) When the participant achieved early completion, or when the time reached 50 minutes, the researcher asked the participant to finish. Upon completion, he advised the participant that the post-activity interview would be recorded, started a new recording, and then sat with the participant to complete the interview.

After the final participant of the day, all data were aggregated from their various locations/environments, organized in folders using a standardized convention, and moved to a secure storage device behind the UOIT firewall. These data included: (a) four, audio-video files produced by Noldus Media Recorder, representing multi-perspective recordings of the activity and the interview; (b) an export of the participant's survey data from SurveyMonkey, in PDF format (to facilitate quick review) and Excel format (with Likert-scale responses saved as numbers for detailed analysis); and (c) screen snapshots of all digital artefacts created by the participant as outcomes of their activity.

Finally, browser caches and stored assets were cleared from the devices to reduce a participant's activity footprint as much as possible without performing a device reset. Some remnants of a participant's data remained on the device for subsequent participants, particularly during the second of two sessions scheduled back-to-back. The researcher observed only a few instances when a participant took notice of an existing artefact. One participant used an existing artefact as a template for their work. In another instance, a participant noticed an existing item in a Google Drive folder, paused, and chose not to use it. Whether the strategic use of an existing artefact ought to be construed as a digital competency—note, for example, Eshet's dimension of Reproduction Digital Skills (Eshet, 2012)—or a weak form of plagiarism, remains an open question deserving discussion. The perceptions of participants appeared split on this issue.

4.4 Analysis

The general analysis procedures, reported here, were developed and refined through a series of exploratory and statistical probes of the audio-video, survey and interview data. They are reported here in their final form.

4.4.1 Survey data

Owing to the manageable sample size and the exploratory nature of this study, full survey data for *each* participant, along with the aggregate data, were exported from SurveyMonkey in multiple formats for review and analysis. A PDF summary of each participant response was produced using the built-in, export function to facilitate a cursory review of individual-level data. A delimited export of the full data set was produced for fuller analysis in SPSS. Although two participants failed to provide responses for the device access and use items, the frequency and confidence items were complete.

4.4.2 Performance activity data

Performance activity assets for each participant were collected and divided into three groups. Group 1 included a video file showing a participant's: (a) face during activity; and (b) device screen and hand-device interactions, including an audio track supporting the optional think-aloud protocol. Group 2 included a folder of assets, aggregated by the researcher, produced as outcomes of the performance activity. Group 3 included an audio-video file capturing the semi-structured, post-activity interview, and some corresponding field notes.

Group 1 data were imported into Noldus The Observer XT for real-time review and qualitative coding, addressing four categories of phenomena: (1) task and scenario durations; (2) problems or challenges (related to confident, strategic and strategic selection of the hardware and software affordances aligned with a task goal); (3) technical failures (related to hardware and software functioning/programing); and (4) two types of "competency demonstrations" related to the application of acquired skills (thought to be most aligned with experience), and displays of adaptiveness and problem-solving (thought to be most aligned with confidence). This coding scheme (Appendix F) adapted elements from previous observational research (Van Deursen, 2010), but was extended through an emergent process of categorizing the challenges participants encountered when addressing an assigned task with the selected device. Had the sample size and the variety and difficulty of the assigned tasks been increased, it is expected that additional types of problems would have emerged. On the basis of this review and coding, the overall quality of an individual's performance on each task was scored from 3 (high quality) to 1 (low quality), using the quality assessment rubric provided in Appendix G. The total time for completing the entire six-task scenario was also recorded. Neither the coding scheme nor the accompanying rubric were subjected to separate processes of formal validation. Rather, within the time constraints of this study, focus was placed on proposing and piloting a conjectural apparatus in a specific context of application.

Group 2 data, the artefacts produced during an activity, and representing performance outcomes, were also scored from 3 (high quality) to 1 (low quality) using the performance assessment rubric shown in Appendix G. Again, within the time constraints of this study, this rubric was not subjected to separate processes of formal validation.

Group 3 data, consisting of an audio-visual recording of the post-activity interview, was reviewed in a media player. An individual's structured response to the scenario difficulty question (Q1) was reduced to the corresponding number (1 = relatively easy; 2 = reasonably challenging; 3 = frustratingly difficult) and noted in a spreadsheet. A textual description of a participant's: (a) most comfortable and uncomfortable tasks, and (b) self-assessed general readiness for online learning using a tablet device was also noted. The production of a transcript and further systematic analysis of the interview data was not pursued. These processes went beyond the scope of this study owing to time constraints, and because the conversations tended to move well beyond the research questions.

4.4.3 Comparison of survey and performance data

Having reviewed the data, a statistical matrix was created in Excel (Appendix J) and comparisons of self-report and performance data were initiated. Statistical correlations were conducted for each of the three groups of participants (organized by the Scenario they performed) at the task and scenario levels. Owing to the small sample size, these correlational results were not generalizable, and therefore, tests for statistical significance were not conducted.

The specific procedures for correlational analyses were as follows. At the task level, the task performance scores (TPS) for each group were statistically correlated to the task reported scores (TRS) for each of the mapped GTCU item. For example, Task 1, Scenario 1, was mapped to GTCU item #16. The TRS was calculated by summing six reported values: frequency of activity using a computer (F1); confidence of activity using a computer (C1); frequency of activity using a smartphone (F2); confidence of activity using a smartphone (C2); frequency of activity using a tablet (F3); and confidence of activity using a tablet (C3). The TPS was calculated by summing the process score (PS) and outcome score (OS), which were calculated by the researcher through systematic timeline coding of recorded video in the Observer XT (using a coding scheme focused on activity strategy and problem mapping, as shown in Appendix F) and an assessment rubric (Appendix G).

The rationale for summing the process and outcomes scores relates to their nature as overlapping, but conceptually distinct constructs, representing two key facets of performance in educational contexts. Importantly, during the scoring of performance activity, significant effort was made by the researcher to assess processes and outcomes as distinct dimensions. The various combinations of process and outcomes scores reflect this. (In some cases, as might be expected, the quality of processes did largely determine the quality of outcomes.)

The rationale for summing six GTCU item values, including both frequency and confidence measures, into a single performance score is rooted in the foundational operational logic of the GTCU framework (Desjardins, 2005). The frequency with which an individual performs an activity and the confidence by which this performance is perceived, function as twin, synergistic indicators. The synergistic nature of these indicators may be understood, for example, by considering that many performance activities that individuals encounter in the formal learning contexts are only loosely associated with prior digital activity. Confidence is the motivational force influencing the general strength of an individual's ability to select and apply relevant experience to new contexts and problems. Similarly, even when an individual possesses consistently high levels of computer-related confidence ("I'll try anything!"), prior experience engaging in a similar type of activity will typically improve the quality of performance.

The rationale for summing frequency and confidence values *from three device types* (i.e., computer/laptop, smartphone and tablet) is rooted in today's general logic of achieving continuous user experiences across platforms. That is, although there are procedural differences, for example, in searching and downloading information on a laptop, smartphone and tablet, there were also environmental consistencies such that a participant's experience and confidence engaging in an activity on one device was expected to influence their ability to perform an aligned task on a different device. This expectation is heightened in our current, cloud-based computing environments in which web browsers function consistently as cross-platform containers for cloud-based applications. Of course, this is not to ignore the sometimes-frustrating adjustments required by users, and observed in this study, as they adjust to device inconsistencies in applications such as Google Drive.

At the scenario level, a scenario performance score (SPS), calculated by summing the six TPS scores, were correlated to the scenario reported score (SRS) generated by summing the TRS for all six tasks. The rationale for the scenario-level correlation was related to the design of performance activities as authentic tasks, with internal consistency, and consequently, various levels of inter-dependence between tasks. In short, it was important to address performance of both individual tasks and the entire activity as a whole.

4.4.4 Case-study analyses of situational influencers of performance

In order to go beyond statistical correlations to deeper investigation of situational factors influencing performance, the qualitative data record, consisting of coded video timelines in The Observer XT and recorded post-activity interviews, were studied for participants from the group showing the lowest level of overall correspondence between reported competencies and performance. This involved five detailed case-study analyses (Merriam, 1998). The goal was to search for situational factors, distinct from those measured by the GTCU, which influence performance. Such factors were expected to relate to task difficulty, participant physical and emotional states, task dependencies within a scenario, technical failures, and/or participant discomfort with the performance device—in short, a variety of situational phenomena. (A full list of selected phenomena, and corresponding codes, are provided in Appendix F.)

4.4.5 Interpreting findings in relation to readiness

Finally, the entire body of quantitative and qualitative findings was reviewed and interpreted to address how the GTCU survey instrument might be used as an effective tool for probing the readiness of participants for successful digital learning. The starting point was the participants with the highest and lowest reported digital competencies. That is, it was conjectured that measured GTCU competencies function most reliably to distinguish between: (a) those who would be almost certainly able to function fully in contexts of digital learning, and (b) those for whom full functioning would almost certainly be a struggle, without significant support or remedial interventions. Having explored these “ends” of a hypothetical readiness spectrum, within our sample, attention was given to establishing a reported-competency score that might function as a threshold—under which all individuals, who were observed to have very troubled performance experiences, could be located. This might suggest a general methodology for further development of the GTCU as a readiness tool.

5 Results

5.1 Overview

Findings addressing research questions 2-4, are addressed in order. RQ2 is addressed largely through quantitative analysis of the dataset. RQ3 is addressed by focusing on five recorded performances as qualitative case studies. The goal is to move beyond the numbers, and look deeper into relationships between reported competencies and the situational dynamics of performance. RQ4 is addressed through consideration of both the quantitative and qualitative data.

5.2 Research Question 2: Relating Self-Reports and Performance

> *RQ2. Do self-reported GTCU competencies, focused on the twin indictors of frequency of activity and activity-related confidence, show positive correlations with performance quality in a context of digital-learning?*

To address this question, correlations are explored between: (a) general digital competencies levels reported via the GTCU survey instrument; and (b) individual performance scores assigned through qualitative analysis of digital-learning activities, captured using multi-perspective, audio-visual recording techniques in the EILAB, and analysed in Noldus The Observer XT. These findings are addressed, first, at the level of individual scenarios (in numbered order), and second, at the aggregate level (i.e., all three scenarios combined).

5.2.1 Performance Scenario 1: "Presentation Planning"

Scenario 1, as detailed in Appendix E (Table A3), asked participants to reflect on a research topic from their own educational experience, and prepare materials for a fictitious presentation in six steps. The tasks of this scenario were mapped to two informational, two epistemological and two social activity items in the GTCU self-report instrument. (These are, in task order—I16, I17, E22, E23, S12 and S11—with full text provided in Appendix D.) Taken together, they offer an authentic research activity, reminiscent of the activities practiced by academics in university settings. Moreover, they include several digital applications (e.g., Google Scholar, Google Calendar and YouTube) often used in fully online courses, such as those at UOIT.

The six participants of this activity had an average, self-reported score (SRS) of 119 with a high of 168 (P1) and a low of 87 (P13), for the items mapped to this scenario. This is well above the 78.3 average (+40.7), for these same items, calculated from the full GTCU database, containing almost 700 profiles of mostly university students. Moreover, all the scores for individual participants exceeded this average. This suggests that the group performing this scenario are weighted towards those at the higher end of a digital-competence spectrum, and perhaps this is to be expected given they are students at a science and technology university, and some have completed fully online courses (as reported in post-activity interviews). Similarly, performance scores are consistently high across all tasks, with 25 perfect scores (out of 36 tasks), which suggests that each task might have been implemented with a greater degree of complexity to promote greater diversity in performance results.

Based on post-activity interviews, Scenario 1 had a perceived difficulty score of 1.7, measured on a 3-point scale: 1 = relatively easy, 2 = reasonably challenging, 3 = frustratingly difficult (see Appendix I). Four of six participants described this activity as “reasonably challenging,” and two described it as “relatively easy.” This finding aligns with the researcher’s general expectation and a calculated scenario rating of 78.3 (Appendix E), suggesting this is the least challenging of the three scenarios. (As shown in Appendix E, Scenario 2 is rated at 72.2, and Scenario 3 at 64.) This rating, calculated from the full GTCU database, represents the Mean sum of all frequency and confidence sub-items (including those for computer, smartphone and tablet) for each of the scenario’s mapped GTCU activities. Smaller values indicate that constituent tasks incorporate GTCU activities with which individuals generally report less experience and confidence.

Table 4

Scenario 1 (“Presentation Planning”). Reported Competency and Performance Summary

Person Number	Device Selected	GTCU Total	Perform Total	Time in Minutes	Task 1	GTCU-I Item 16	Task 2	GTCU-I Item 17	Task 3	GTCU-E Item 22	Task 4	GTCU-E Item 23	Task 5	GTCU-S Item 12	Task 6	GTCU-S Item 11
P1	iPad	168	36	32	6	30	6	30	6	30	6	18	6	30	6	30
P8	iPad	135	36	39	6	21	6	26	6	24	6	15	6	23	6	26
P6	iPad	119	36	29	6	14	6	27	6	12	6	9	6	29	6	28
P12	iPad	113	34	23	6	20	6	21	5	16	6	6	6	23	5	27
P3	Sam	92	30	49	4	13	5	25	5	13	6	6	6	16	4	19
P13	Sam	87	30	40	4	22	5	15	5	7	5	10	5	8	6	25
Correlations		**.83 (high+ overall)**			.31 (med+)		.59 (high+)		.65 (high+)		.07 (low+)		.8 (high+)		.79 (high+)	

As presented in Table 4 above, for the six participants performing this scenario, higher GTCU item scores were correlated with higher task performance scores for each of the six tasks. Moreover, four of the tasks produced correlation coefficients greater than .5, indicating a large effect (Task 2: r=.59; Task 3: r=.65; Task 5: r=.8; Task 6: r=.79). Task 1, which related to finding a journal article on Google Scholar, produced a medium-range coefficient (r=.31). Task 5, which related to preparing a basic concept map, produced a low-range coefficient (r=.07). However, in both cases, performance scores were consistently high, and the participants with the lowest ranked, self-reported competency achieved scores slightly lower than the majority. (P3 and P13 scored 4 for Task 1. P13 scored 5 for Task 4.)

Total scenario time was recorded, and a noteworthy grouping emerged. The three participants with the highest (in this case, perfect) performance scores (P1, P8 and P6), completed the scenario in 32, 39 and 29 minutes respectively. The two participants with the lowest performance score (P3 and P13), completed the scenario in 49 and 40 minutes. Participant 12 had the fastest completion times at 23 minutes, and appeared to be an operational virtuoso on the selected iPad device. However, this participant reported the activity as "relatively easy," and displayed signs of hasty execution, and consequently, the quality of task outcomes suffered. This highlights the precarious nature of time-on-task as a criterion for competency assessment.

At the scenario level, total reported competency scores (maximum of 180) were correlated with total performance scores (maximum of 36), r.=.83, which may be considered a large effect size. Therefore, at the aggregate level, this scenario produced results in which reported competencies show a strong positive relationship with performance quality.

5.2.2 Performance Scenario 2: "Democracy Data Analysis"

Scenario 2, as detailed in Appendix E (Table A4), involved preparing for a symposium, addressing the themes of education and democracy, which included accessing the online World Values Survey (WVS) database, related to the international study of changing values and their impact on social and political life. More specifically, this six-step activity asked participants to select and manipulate WVS data, and share this data with a collaborator via text messaging and email. The tasks of this scenario were mapped to one informational, two epistemological and three social activity items in the GTCU self-report instrument. (These are, in task order—I15, E25, S13, E26, S8 and S11—with full text provided in Appendix D.) Taken together, and like Scenario 1, they offered a sequenced activity incorporating typical repertoires practiced by students and professors in university settings. Moreover, they incorporate digital applications (e.g., Google Sheets and Facebook Messenger) often used in fully online courses, such as those at UOIT.

The four participants of this activity had an average, self-reported GTCU score of 86.3 with a high of 99 (P5) for the items mapped to this scenario. This is above the 72.2 average (+14.1), for these same items, calculated from the full GTCU database of almost 700 profiles. This again, suggested that participants performing this scenario are weighted towards the higher end of a GTCU digital-competence spectrum. However, among the participants, P4 reported a general competency score of only 62 on mapped items—the lowest reported GTCU score in the entire study. Moreover, performance scores generated from Scenario 2 show greater diversity across all participants than those produced by Scenario 1. This is likely related to the levels of complexity of Tasks 2, 3 and 4, and their dependent/progressive nature. (Task dependence and progression is an expected characteristic of many authentic activities.) Participants who stumbled in Task 2 (P2 and P4), which required that one query and extract data from an online database, could not fully complete Tasks 2 and 4, which required the manipulation and visualization of the extracted data. Indeed, even those who completed Tasks 2 and 3 (P5 and P10), stumbled on Task 4, which required the data to be interpreted and graphed. This is not surprising because Task 4 was based on GTCU-E item #23, with a 7.1 average competency score in the full GTCU database (Appendix E, Scenario 2). This fell below the 10.8 average for the full set of 21 items of the social, informational and computational dimensions, and suggests a high level of potential difficulty. In fact, as shown in Appendix D, this item had the third lowest general competency score.

To probe scenario difficulty further, based on post-activity interviews, Scenario 2 had a perceived difficulty score of 2.5, measured on a 3-point scale (1 = relatively easy, 2 = reasonably challenging, 3 = frustratingly difficult), the highest of the three activities in this study. Two of the four participants described this activity as “frustratingly difficult,” and two described it as “reasonably challenging.” This level of perceived difficulty was consistent with a calculated GTCU competency rating of 72.2 for this scenario as shown in Appendix E, which is less than that for Scenario 1. The reported level of difficulty is also consistent with the logical dependence of Tasks 2-4, a complex, connected sequence.

The recorded scenario times are also consistent with reported perceptions of difficulty. Participant 5 completed the activity in 29 minutes with a high, performance score of 33 (out of 36). The other participants took the maximum time of 50 minutes, and two of these (P2 and P4) failed to complete the scenario. In fact, Participant 4, who was new to tablets, failed to get beyond the first task. Therefore, unlike in Scenario 1, a shorter time completing Scenario 2 was a strong indicator of more effective performance.

As presented in Table 5 below, for the four participants performing this scenario, higher GTCU item scores were correlated with higher task performance scores for each of the six tasks. Moreover, like in Scenario 1, four of the tasks produced correlation coefficients greater than .5, indicating a large effect (Task 1: r=.66; Task 2: r=.77; Task 3: r=.69; Task 4: r=.9). Task 5, related to text-messaging a fictitious collaborator on Facebook Messenger, produced a low-range coefficient (r=.19). Task 6, which required participants to send an email with the materials produced during the activity, produced a medium-range coefficient (r=.43). These tasks were mapped to the two GTCU items having the highest general competency scores, in the full database, of all 21 items of the social, informational and computational dimensions, and therefore, might be considered “relatively easy.” (S8 has an average of 2.7, and S11 an average of 2.8.) This suggests that high performance on easier tasks may be less dependent on prior experience and confidence.

Table 5

Scenario 2 (“Democracy Data Analysis”). Reported Competency and Performance Summary

Person Number	Device Selected	GTCU Total	Perform Total	Time in Minutes	Task 1	GTCU-I Item 15	Task 2	GTCU-E Item 25	Task 3	GTCU-S Item 13	Task 4	GTCU-E Item 26	Task 5	GTCU-S Item 8	Task 6	GTCU-S Item 11
P5	iPad	99	33	29	6	18	5	10	6	21	4	9	6	19	6	22
P2	iPad	92	16	50	4	19	2	6	2	12	2	6	3	27	3	22
P10	iPad	92	27	50	4	14	5	18	6	13	4	12	4	18	6	17
P4	iPad	62	13	50	3	12	2	8	2	11	2	6	2	12	2	13
Correlations		**.76 (high+ overall)**			.66 (high+)		.77 (high+)		.69 (high+)		.9 (high+)		.19 (low+)		.43 (med+)	

At the scenario level, total reported competency scores were correlated with total performance scores (maximum of 36), r.=.76, which may be considered a large effect size. Therefore, this scenario, like the previous one, produced results in which reported competencies show a strong positive relationship with performance quality.

5.2.3 Performance Scenario 3: “Model Drawing”

Scenario 3, as detailed in Appendix E (Table A5), involved developing and sharing conceptual materials for a research project related to the study of online learning. More specifically, this six-step activity asked participants to find, modify, manage and share visual materials and a bibliographic reference. The tasks of this scenario were mapped to one epistemological, two informational and three social activity items in the GTCU self-report instrument. (These are, in task order—S13, I18, E24, I20, I14 and S11—with full text provided in Appendix D.) Taken together, they offer an authentic research activity like Scenario 1 and 2. Moreover, they also incorporated digital applications (e.g., Google Drive and the social-sharing platform, Padlet) used in fully online courses, such as those at UOIT. Importantly, the core of this scenario, Task 3, required the participant to draw a visual model based on a conceptual description and a related model. As shown in Appendix D (Table A1 and A2), this task was based on GTCU-E item #24 with a 6.9 competency score in the full GTCU database, the fourth lowest average competency ranking. Therefore, it was expected to be a challenging task.

The five participants of this activity had an average, self-reported GTCU score of 116 with a high of 137 (P14) and a low of 101 (P11) for the items mapped to this scenario. This is well above the 64 average (+52), for these same items, calculated from the full GTCU database (see Appendix E, Table 5). Therefore, of all three groups, this one exhibited the greatest positive differential between their average general competency score, and the average (for the same items) calculated from the full database. Once again, this suggests the participants are weighted well towards the higher end of a GTCU digital-competence spectrum.

Performance scores in this group of five were diverse, with only five perfect scores. (Scenario 1 produced 25 perfect scores with six individuals, and Scenario 2 produced 6 with only four.) Not surprisingly, the expectedly difficult Task 3, discussed above, produced no perfect scores and was observed to present a significant challenge. Surprisingly, Task 6 based on GTCU-S item #11 ("to communicate with others using email") also produced no perfect scores despite the reported competency scores being well above the 16.8 average. Similar email tasks in the other two groups produced six perfect scores. This finding suggests that regardless of a participant's general competency in a certain sphere of activity, situational variables may function to heighten or soften the level of challenge. In this case, individuals were struggling to manage and attach digital assets produced in multiple applications on a tablet device, which increased the difficulty of completing an effective email. (File management is often perceived as more difficult on a tablet than a laptop/desktop, because of inconsistent functionality across applications. A closer exploration of Scenario 3 performances is conducted below.)

Scenario 3 had a perceived difficulty score of 2.2, measured on a 3-point scale (1 = relatively easy, 2 = reasonably challenging, 3 = frustratingly difficult), the second highest of the three activities in this study. This was owing to the fact that two participants (P15 and P9) situated this scenario between "reasonably challenging" and "frustratingly difficult" during the interview. This level of perceived difficulty was consistent with a calculated GTCU competency rating of 64 for this scenario, as shown in Appendix E. Although this scenario might be expected to have a higher perceived difficulty rating than Scenario 2, with a rating of 72.2, all things were not equal. For example, the digital competency score of every participant in Scenario 3 was higher than every participant of Scenario 2. (Greater overall competency would be expected to reduce the level of perceived difficulty.) Moreover, Scenario 3 did not possess the same degree of task dependence as Scenario 2. Finally, owing to the circumstances of back-to-back scheduling, at least two participants in Scenario 3 were seen consulting artefacts left on the device by a previous participant, which provided scaffolding for their efforts.

The recorded scenario times ranged from 22 minutes (P7, achieving a performance score of 30) to 57 minutes (P9, achieving a performance score of 33). In this group, higher overall performance scores showed a positive correlation with *higher* completion times, with a medium effect (r=.2). Whether saving 35 minutes while surrendering only three performance points might be construed as highly effective or somewhat impatient functioning, is a difficult question. In university contexts where course instructors offer thick syllabi featuring numerous assignments with tight deadlines, one cannot dismiss the value of speed. Indeed, in constantly changing and demanding, professional contexts beyond the university, "keeping up" is often a survival skill.

Table 6

Scenario 3 ("Model Drawing"). Reported Competency and Performance Summary

Person Number	Device Selected	GTCU Total	Perform Total	Time in Minutes	Task 1	GTCU-S Item 13	Task 2	GTCU-I Item 18	Task 3	GTCU-E Item 24	Task 4	GTCU-I Item 20	Task 5	GTCU-S Item 14	Task 6	GTCU-S Item 11
P14	Sam	137	27	50	5	27	5	28	4	9	4	20	4	27	5	26
P7	iPad	120	30	22	5	21	6	25	3	6	5	20	6	22	5	26
P15	Sam	112	28	42	5	13	5	21	5	9	3	15	5	24	5	30
P9	iPad	110	33	57	6	19	6	24	5	14	6	16	5	12	5	25
P11	Sam	101	24	41	4	17	4	21	2	9	5	12	5	15	4	27
Correlations		**.09 (low+ overall)**			.14 (low+)		.43 (med+)		.56 (high+)		-.05 (low-)		-.28 (low-)		-.06 (low-)	

As presented in Table 6 above, for the five participants performing this scenario, correlations between GTCU item scores and task performance scores were inconsistent. The first four tasks, generated correlations in the expected, positive direction. Task 1 produced a correlation coefficient less than .3 indicating a small effect (r.=.14). Task 2 produced a correlation coefficient greater than .3, indicating a medium effect (r.=.43). Task 3 produced a correlation coefficient greater than .5, indicating a large effect (r.=.56). However, Tasks 4-6 produced negative correlation coefficients, all lower than .3 (Task 3: r.=-.05; Task 4: r.=-.28; Task 5: r=-.06). In short, for half the scenario, differences in self-reported competencies were not statistically related to task performance in the expected direction, and further investigation into the details of individual performances are explored below.

At the scenario level, total reported competency scores were correlated with total performance scores (maximum of 36), r.=.09, which may be considered a small effect size. Therefore, taken as a whole, this scenario, like the previous two, produced results in which reported competencies show a positive relationship with performance quality.

5.2.4 Aggregate level results

Looking at all 15 participants across the three activities designed for this study (Table 7 below), higher GTCU item scores were correlated with higher scenario performance scores, producing a correlation coefficient greater than .5, indicating a large effect size (r.=.66). This finding suggests that the GTCU has the potential to function as a useful probe for anticipating levels of student performance in contexts of digital learning, and will be explored below.

Table 7: Aggregate Level Results Sorted by Total GTCU Scores

Person Number	Activity Number	Perceived Difficulty	GTCU Total	Perform Total
P1	1	2	**168**	**36**
P14	3	2	**137**	**27**
P8	1	2	**135**	**36**
P7	3	2	**120**	**30**
P6	1	1	**119**	**36**
P12	1	1	**113**	**34**
P15	3	2.5	**112**	**28**
P9	3	2.5	**110**	**33**
P11	3	2	**101**	**24**
P5	2	2	**99**	**33**
P3	1	2	**92**	**30**
P2	2	3	**92**	**16**
P10	2	2	**92**	**27**
P13	1	2	**87**	**30**
P4	2	3	**62**	**13**
			Correlation Coefficient: .66 (high+)	

5.3 Research Question 3: Mining the Gaps with Video Analysis

RQ3. What "gaps" emerge between the self-report data and performances of individuals in specific activity contexts, and how can these gaps be explained? That is, what types of variables not addressed by the GTCU, appear to have a significant influence on performance?

In order to address this research question, five detailed (case-study) analyses, featuring the participants of Scenario 3 were conducted. These participants produced the greatest statistical misalignments between reported competencies and performance quality. By moving beyond the statistics to thicker descriptions of the performance activity, various situational and contextual variables influencing performance, and beyond the reach of the GTCU survey instrument, were observed. These descriptions are based on analysis of synchronized audio-video recordings of performance activity in The Observer XT, captured from two close-up perspectives, featuring: (a) hand-device interactions and screen activity, and (b) the participants face. Each case study is introduced by a participant number as shown in Table 8.

Table 8: Scenario 3. Participant Performance Case Studies

	Participant	Gender	Age	Educ. Level	Specialization	Devices Used	Principal Use
Activity 3	P7	Female	23	Bachelors	Education	Laptop Smartphone Tablet	Study Social **Teaching**
	P9	Male	22	Bachelors	Education	Laptop Smartphone	Study Work
	P11	Female	30	Bachelors	Education	Laptop Smartphone Tablet	Study Entertainment **Entertainment**
	P14	Female	22	Bachelors (Graduated)	Commerce	Laptop Smartphone Tablet	Entertainment Work **Entertainment**
	P15	Female	51	Post-Doctoral	Economics	Laptop Smartphone Tablet	Work Social **Entertainment**

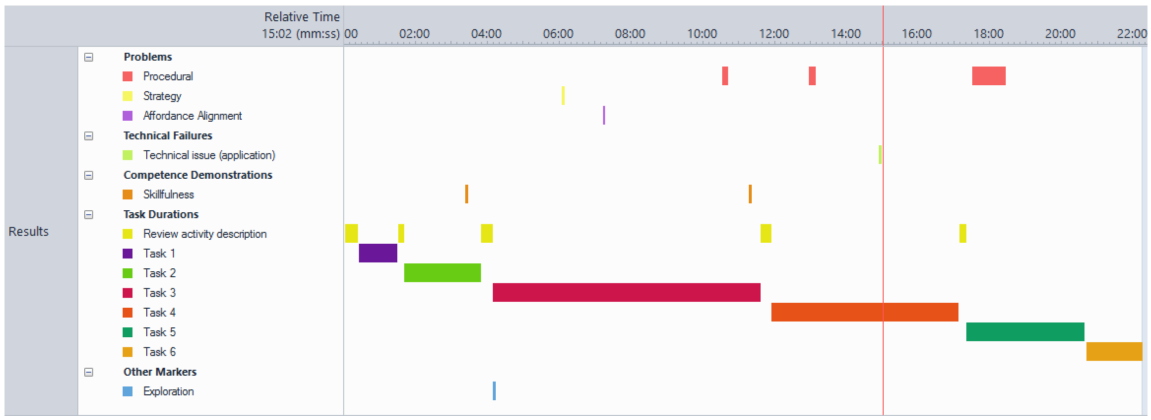
To aid in reporting the performance activities, coded visualizations are presented for each participant as prepared in The Observer XT. These visualizations plot colour-coded events to a timeline representing the full duration of the performance. They provide a means to reference events in the audio-visual data (time is in minutes from start of activity), and they also offer a useful visual for comparing task-completion durations and start-stop patterns both within a single performance activity and across participants.

5.3.1 P7. Speedy operational virtuoso

Participant 7 was a 23-year-old female, and an undergraduate student in education. She had a GTCU competency score of 120 for the six aligned items—well above the 64-average calculated from the full GTCU profile dataset. She owned a laptop, smartphone and tablet. The primary uses of these devices were reported as studying (laptop), social (smartphone) and teaching (tablet). That the tablet was used primarily for teaching appears significant because seven of 12 individuals in this study owning a tablet reported entertainment as the primary use. (Entertainment uses, such as watching movies, tend to involve less active forms of interaction, which might not develop the same breadth and depth of skills as more active, production-oriented interaction.) Indeed, no other participant reported teaching as the primary use for a tablet. It is noteworthy, however, that she reported no experience or confidence using any device to create, modify or use conceptual drawings—the basis of Task 3.

She appeared very confident throughout the activity, particularly with the operational features of Apple's iOS, completing the activity in 22 minutes with a performance score of 30 (out of 36)—16 for procedural quality, and 14 for outcomes/artefacts quality. As shown in the performance timeline visualization in Figure 5 below, two Competence Demonstration events, coded as Skillfulness, highlight this operational comfort. More specifically, the video revealed little hesitation or confusion as she changed the device settings to allow Google Drive to access a local photo (3:26). Similarly, she effortlessly used the iOS key combination, made awkward by the controlled positioning of the device, to take a screenshot to circumvent the need to export a file in a sharable format using an application's built-in function (11:20). (Other participants struggled with these items.)

Figure 5. Coded Performance Timeline of P7



A high level of general confidence was also exhibited by the consistent and calm demeanour as judged by this researcher through observations of the participant's head movements and facial expressions. No incidents of frustration were observed/coded. Moreover, the participant maintained a well-managed and goal-driven flow of activity as evidenced by the structure of task completion, and only one period of exploratory activity, indicating that she developed solutions quickly and decisively.

In fact, it appeared to be quick decision-making and an aggressive pace that precipitated less than perfect outcomes-quality scores on Tasks 3, 4 and 6 (included in Appendix J). From a process-analysis perspective, three problems were coded. Three Procedural problem events were observed. The first two appeared related to using prescribed, native applications (Mindomo and Padlet) for the first time (10:32 at the end of Task 3, and 17:30, at the beginning of Task 4). The third involved trying to find a book reference in APA format. These issues are of minor significance, and likely would disappear quickly through additional related use. The other coded problems occurring in the context of Task 3 (a task expected to be difficult) appear more significant.

Strategy and Affordance Alignment problem-markers appear at 6:05 and 7:16 of Task 3 as the participant looked for a way to draw a conceptual model. Prior to this, she scanned the device very quickly and easily for installed applications. Rather than go online to download an application that would allow her to draw, position and label shapes to create a model similar to the reference model, which she successfully downloaded from Google Images, she opted for an application already installed on the tablet—a mind-mapping tool. Her facial expressions during this segment of video suggested some recognition of the problem. She looked unsettled and unconvinced that the mind-mapping application suited the purpose of the task. She explored an existing concept map and appeared dissatisfied. She called up the reference model and studied it. She returned to the mind-mapping program, her facial expression suggested mild disgust. She reviewed the task description briefly and unsuccessfully tried to find a concept-map template that provided the elements required. At 5:41, she smiled somewhat sheepishly, and once again reviewed the installed affordances. At 5:52, she used the Apple Store to search for a free alternative (of which there are many). Strangely, she searched for "concept map," saw more of the same, and then grudgingly returned to Mindomo to construct a model that looks nothing like the exemplar provided.

This episode had little to do with the types of digital competency measured by the GTCU. Rather, it related more to the participant's level of engagement and task commitment. Indeed, this episode stands in sharp contrast to next case study, where we encounter an exceeding calm, exploratory and committed performer, refusing to take steps towards the task goal until the most suitable tool had been found. The penalty to Participant 7, for poor tool-alignment, is a lower overall performance score.

In the end, reporting Scenario 3 as reasonably challenging, Participant 7 positively stated her readiness for fully online learning using a tablet device. Her observational timeline suggests very reasonable self-awareness in this regard.

5.3.2 P9. Patient, steady and resourceful, wins the (quality) prize

Participant 9 was a 22-year-old male, and an undergraduate student in education. He had a GTCU competency score of 110 for the six aligned items—well above the 64-average calculated from the full GTCU profile dataset. He owned a laptop and smartphone only—the primary uses of which were reported as studying (laptop) and working (smartphone). The lack of tablet ownership is noteworthy, and it helps frame the cautious and exploratory approach to scenario completion. However, he did report using a tablet "a few times per year" for four of the six aligned tasks. Therefore, he brought some relevant experience to this performance scenario. Importantly, he also reported moderate to high confidence in his ability to perform all six of the aligned tasks using a tablet, apparently reasoning, like many, that experience using a laptop and smartphone would transfer to the lesser used device.

Participant 9 appeared operationally capable and deeply engaged throughout the activity, but particularly during his lengthy and precise execution of Task 3, a difficult task. As evidence of this engagement, he reported afterwards that “this was definitely a fun experience…really fun.” In this case, high engagement was matched by a high, performance score of 33 out of 36 (the best in the Scenario 3 group) with a near perfect 17 process score.

As shown in Figure 6, his skilfulness and patience was marked near the beginning of Task 3 (starting at 7:45) as he began a careful search for a task-appropriate drawing application. He searched for free, native applications on the Apple Store, and tried out the features of four such apps. Eventually, he turned to Google (16:38), entered “diagram creator” as a search phrase, selected the cloud-based Draw.io, and swiftly completed the Google Drive integration steps to manage his work. (Using a feature-rich, cloud-based application that could be accessed via a browser was not considered by any other participants in this group.) At 19:06, he used Google to seek out procedures for producing transparent shapes in Draw.io. Through this entire sequence, which runs from 7:14 to 31:44 on the timeline, and ends with a smile of accomplishment, Participant 9 displayed patient persistence, apparently focused on achieving a high-quality product. His persistence continued when, around the 32-minute mark, and having reviewed the activity description, he realized he had drawn the wrong model. He quickly returned to the task, spending another 12 minutes applying his new-found skills to the correct model.

Figure 6. Coded Performance Timeline of P9

Participant 9’s visible confidence and keen focus, punctuated by brief smiles of understanding and accomplishment, continued throughout the activity. No incidents of frustration were observed. Moreover, the participant maintained a well-managed and goal-driven flow of activity as evidenced by the structure of task completion, and only one period of exploratory activity (50:49), when having been advised that 50 minutes had elapsed, he doubled-checked his interpretation of “two dimensions” as presented in Task 3.

The problems coded for this participant were minor. During Task 2, there was some hesitation when trying to use Google Drive, and this brief episode was punctuated by a technical issue in which a file, stored on the device, did not appear to be loading in the Google Drive dialog box. (The file status was marked with “waiting,” presumably as the file was transferred to cloud storage). However, this problem was handled without visible frustration by simply repeating the process. At 13:42, during the early portion of Task 3, a Task Comprehension problem led the participant to draw the wrong conceptual diagram the first time around, as noted above. Here again, he patiently repeated the required processes, and achieved a high-quality result.

Owing to the almost 30 minutes allotted to Task 3, Tasks 4-6 were completed in a somewhat rushed and scattered fashion. The participant also maintained a lingering concern for the outcome of Task 3, expressed by repeated checking of his prior work. After the activity, Participant 9 reported being least comfortable "when trying to find a suitable drawing program," and most comfortable when he "finally selected Draw.io." In the end, for this participant, patience, diligence, confidence to try new things, and the dexterity to solve problems on-the-fly, all contributed to the high-quality results.

Reporting the perceived difficulty of Scenario 3 as somewhere between "reasonably challenging" and "frustratingly difficult," he very calmly and positively stated his readiness for fully online learning using a mobile device. This claim appeared well aligned with the analysis of performance.

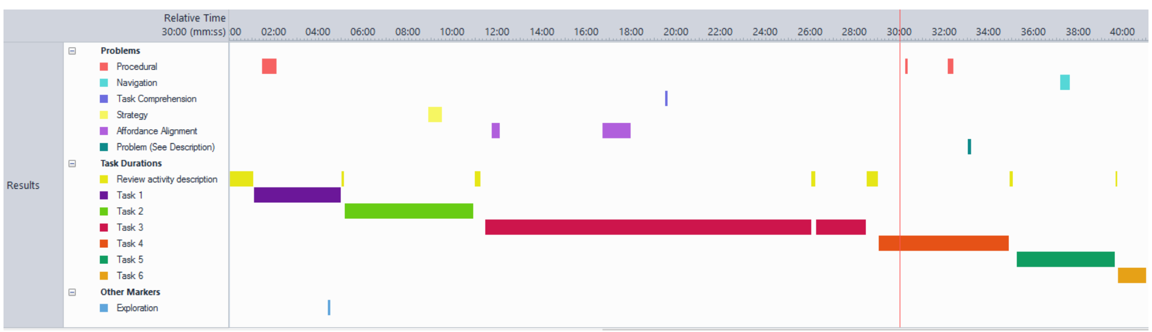
5.3.3 P11. Taking it all in stride

Participant 11 was a 30-year-old female, and like the previous two participants, an undergraduate student in education. She had a GTCU competency score of 101 for the six aligned items—the lowest of the Scenario 3 group, but above the 64-average calculated from the full GTCU profile dataset. She owned a laptop, smartphone and tablet—the primary uses of which were reported as studying (laptop), entertainment (smartphone and tablet). The use of the smartphone and tablet primarily for entertainment aligned with post-activity expressions of discomfort with the tablet for performing educational and production tasks. She stated with emotion, "I really wanted a mouse and a keyboard!"

Participant 11 generally appeared slightly hesitant with the device, adopting a somewhat meandering approach to task completion. At times, she appeared to lose her sense of orientation and became distracted. She completed the activity in 41 minutes with a performance score of 24 out of 36—12 points each for the quality of processes and outcomes—resulting in the lowest total score of this group. No specific competence demonstrations were coded. However, as the timeline suggests, the scenario was addressed in an overall structured and logical manner. Importantly, as an accompanying general observation, this participant never appeared to achieve an intense focus (i.e., enter a "state of flow"), sipping on coffee as she worked. At the same time, no incidents of frustration were observed. In short, she appeared to take a relaxed, if somewhat uncommitted, approach to the activity.

As shown in Figure 7, six types of problems were coded for this participant, distributed throughout the first five tasks, with Tasks 3 and 4 generating the most occurrences (7 total issues). Almost immediately, in Task 1, there was difficulty setting up a folder in Google Drive, and indeed, the participant noted her discomfort with the tablet version of this application in the post-activity interview. She explained how she used Google Drive extensively on a laptop where it had a different interface. This explanation relates to one's ability to abstract general characteristics of the desktop application, and "map" them to a touch interface. It also relates to Google's decision to position their "New" button at the bottom right of the interface—the last place users tend to look owing to well-established top and side-positioning of menus. (Several individuals in this study spent significant time looking for this function, and there was a consistent pattern of exploring the top of the interface.)

Figure 7. Coded Performance Timeline of P11



Task 3 is coded with both Affordance Alignment and Task Comprehension problems. Like Participant 7, a concept-mapping application was selected to do the work of a drawing program. Insufficient task comprehension added to this problem. The participant started the activity by selecting an exemplar model that had no connection to this task description. In fact, it appears the model may have been selected owing to its visual structure and greater similarity to the types of web-like visuals that can be created by a concept-mapping tool. In short, this may have been a case of "the tail wagging the dog." That is, Participant 11 may have considered it more convenient to select a model outside the task description and use a concept-mapping tool, than to find a drawing program to create the model described by the task. This again, speaks to the rather uncommitted posture adopted by this participant.

Task 4 was coded with Procedural problems encountered while searching for a bibliographic reference for a recent academic book, and reproducing it in APA format. The entire execution of this task moved forward clumsily, beginning with a slow, and eventually abandoned, Google search, and then on to a failed effort to use Citation Machine. This is despite the fact that, in the post-activity interview, this participant claimed to be most comfortable searching for information. However, perhaps bibliographic information was beyond her level of comfort.

Reporting the perceived difficulty of Scenario 3 as "frustratingly difficult," she expressed mixed feelings about her readiness for participating in fully online learning using a tablet device. Moreover, she noted discomfort with the prospect of having to manage files on a tablet, and be productive with a touch-based device. She also claimed not to be "a big fan of using a web cam"— presumably with reference to online courses at UOIT that rely heavily on web conferencing to support social-constructivist learning. From an observational perspective, she appeared capable of performing at a higher level, if she were to develop the requisite motivation to do so. (Importantly, her GTCU profile did not display consistent patterns of low confidence across the tasks mapped to this Scenario.)

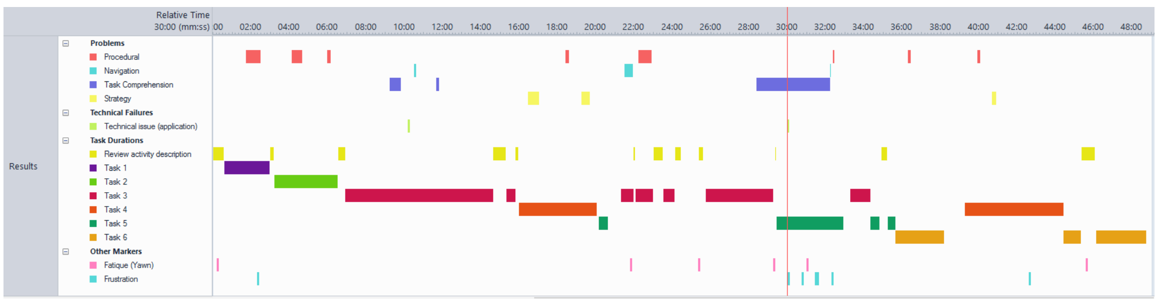
5.3.4 P14. A solid, if tired and circuitous, effort

Participant 14 was a 22-year-old female, and a recent graduate of UOIT's Bachelor of Commerce program. She had a GTCU competency score of 137 for the six aligned items—well above the 64-average calculated from the full GTCU profile dataset—the highest in this group, and second highest in the study. She owned a laptop, smartphone and tablet. The primary uses of these devices were reported as entertainment (laptop), work (smartphone) and entertainment (tablet). The primary uses reported for the laptop and smartphone may reflect the fact that she was a recent graduate now looking for employment opportunities. The prior use of the tablet for entertainment is typical, and can indicate little experience performing production tasks on such a device. However, this participant reported high levels of confidence using the tablet to perform four of the six activities embedded in this scenario.

This was the first participant in the group (and one of four in the entire study) who selected the Android-based, Samsung device rather than the iPad to perform the Scenario. Overall, she appeared very comfortable with this device. Her operational knowledge, for example, was demonstrated by the apparent ease with which she switched between tasks. At the same time, with respect to general disposition, she appeared rather fatigued and occasionally agitated as she performed the activity in 50 minutes (the time at which participants were asked by the researcher to finish) with a performance score of 27 out of 36—losing most points for process quality.

As shown in Figure 8 below (p. 64), this participant's activity was a busy mix of starts and stops, punctuated with 17 instances of four types of problems, and two software-related technical failures. (This participant's activity generated the most codes of any in this study, and the number of shifts in focus made the activity difficult to analyse.) Overall, the execution strategy appeared to be driven by irritation as much as by planning. The five signs of fatigue (extensive yawns and, at one stage, apparent trouble staying alert), and the five signs of frustration (demonstrated by facial expressions of agitation and forceful, repeated tapping on the device screen when an application looked nonresponsive) tell much of the story. However, it didn't tell the whole story. Most of problems and expressions of frustration were situated between 6:56 and 34:21, during a scattered execution of the difficult Task 3, in which a segment of Task 4 (16:00-20:00) and two segments of Task 5 (20:10-38, and 29:25-32:54) were injected (perhaps as respites).

Figure 8. Coded Performance Timeline of P14



During this almost 30-minute period, two software technical issues were noted. First, Microsoft PowerPoint, which was selected to draw the required conceptual model, crashed. Once restarted, and the model completed, it became apparent to the participant that it was not well integrated with Google Drive, which was designated by the researcher as a cloud storage application for this activity. (Microsoft promotes OneDrive as a preferred cloud storage solution, and integrates support for Dropbox.) In addition, while taking a break from Task 3 to access Padlet, this online social-media application appeared to freeze. This event was followed by repeated expressions of frustration, punctuated by a significant yawn. In general, this performance appeared to be a "perfect storm" of human agitation and software issues. The coded Task Comprehension problems all relate to the participant misreading the description of Task 3, and drawing the wrong model. Two other participants (9 and 11) also struggled with interpreting this task—Participant 9 corrected his mistake by reviewing the task description after he had initially drawn the wrong model. In both this case and the case of Participant 11, a somewhat diminished level of focus was visible.

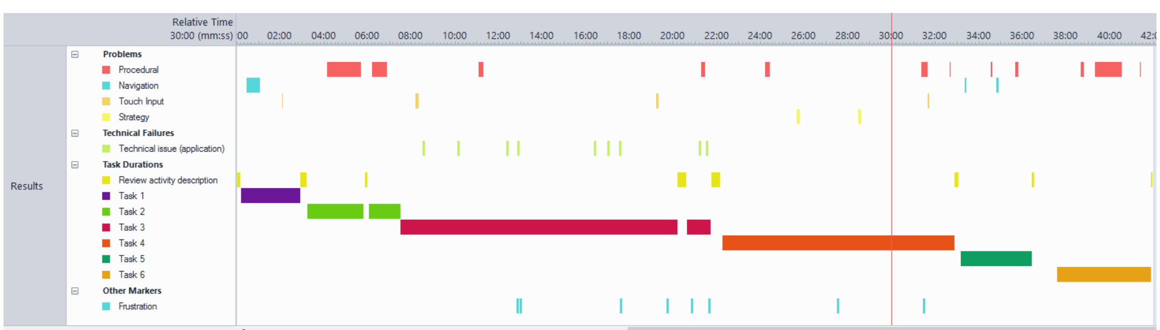
At the completion of the activity, a brief interview was held. She reported the difficulty of Scenario 3 as "reasonably challenging," and she expressed readiness for fully online learning with a tablet device. Finally, she reported being most comfortable when using Google apps, and least comfortable drawing on the tablet and using Padlet. This aligned with the visible expressions of frustration during the activity.

5.3.5 P15. A frustrated but committed performance

Participant 15 was a 51-year-old female, and post-doctoral Visiting Scholar at UOIT's faculty of education, studying digital learning and culture. She had a GTCU competency score of 112 for the six aligned items—like all participants in this group, well above the 64-average calculated from the full GTCU profile dataset. She regularly used a laptop, smartphone and tablet. The primary uses of these devices were reported as working (laptop), social (smartphone) and entertainment (tablet). The prior use of the tablet for entertainment is typical, and can indicate little experience performing production tasks on such a device. However, except for Tasks 1 and 5 (the two tasks with the lowest expected difficulty), this participant reported medium to high levels of confidence for using a tablet to address the task goals included in this scenario.

Participant 15 was the second individual in this group (and, only one of four in the study) to select the Samsung device rather than the iPad, and generally, she appeared *uncomfortable* interacting with the device. At times, touch interactions appeared awkward, lacking adequate pressure and out-of-sync with application responses. Four Touch Input problem events were coded over three different tasks and software applications. Prominent periods of hesitation accompanied these events, suggesting that the participant was gaining familiarity with the interface characteristics of this device on the fly. Regardless of the low comfort, this participant achieved a performance score of 28 out of 36. For four tasks, outcomes-quality scores exceeded process-quality scores. This contrasts with Participant 7, the first case-study of this group, whose operational virtuosity did not always lead to high outcomes scores. The gap between operational competency and high levels of performance in digital learning contexts aligns with the findings of digital-competency research (Eshet-Alkalai & Chajut, 2010).

Figure 9. Coded Performance Timeline of P15



Beyond the four Touch Input problems, addressed above, 12 Procedural, three Navigation and two Strategy problems were coded, as shown in Figure 9. Most of these occurred independently from the instances of software problems and expressions of frustration, and therefore, will be handled separately. The Procedural problems group into six types. First, four instances related to struggles with information management functions such as copying and pasting, and saving copied textual information to a saved document (Task 4 at 31:32 and 32:34; Task 6 at 38:40 and 41:21). Second, three instances related to difficulties with saving and accessing files, particularly in relation to using Google Drive (Task 2 at 4:07 and 6:13; Task 3 at 21:15). The file-management problem at 21:15 was exacerbated by Microsoft PowerPoint's poor integration with Google Drive on the Android-based tablet (as noted above with Participant 14). Third, two instances related to learning a new application (Padlet), understanding the interface and assigning meaning to icons (Task 5 at 34:33 and 35:38). Fourth, one instance related to struggling with a PowerPoint drawing feature—managing shape fills (Task 3 at 11:06). Fifth, one instance related to moving effectively between running applications (Task 6 at 39:17). Finally, one instance related to searching Google Scholar but not checking the second page for results (Task 4 at 24:15). This last issue was especially significant because not only does effective information searching represent a vital aspect of academic practice in a digital age, but in this particular instance, the desired information was located at the top of Google Scholar's Page 2, search results. (This was discovered by the researcher and participant during the post-activity interview in response to the participant's complaint about Google Scholar.)

Two coded Navigation problems relate to the positioning of the New/Open button at the bottom right of the interface in Google Drive (Task 1 at :26) and in Padlet (Task 5 at 34:46). As noted above, this button positioning was confusing to other participants in this study. Responsibility for confusion must be shared with the interface designers, who strayed from well-developed user expectations. A third Navigation problem (Task 5 at 33:22) was encountered when trying to locate the Padlet application on the device. It appeared that general unfamiliarity with the icon/brand made the search difficult. (This participant also reported that English was her third language, and was acquired recently in life. This may have been a factor in relation to the overall speed of interactions.)

Two Strategy problems were coded in the context of Task 4 (25:38 and 28:22), focused on gathering bibliographic information for an academic book. Both of these problems related to finding an appropriate database for book information, and entering effective search terms.

Eight instances of Frustration were coded for this participant, who was conducting this activity late in the day, after a long day of work. Frustration levels were no doubt increased by the repeated crashing of Microsoft's Android-based version of PowerPoint. In fact, the first six Frustration events, made visible through facial expressions and expressive hand gestures, are located in proximity to these repeated crashes during the execution of Task 3 (between 12:45 and 21:44). The other two expressions of frustration occurred during the bibliographic search when the desired information did not appear on the first page of Google Scholar results (Task 4 at 27:28

and 31:25). Here, the frustration response appeared to obfuscate the more strategic response of checking additional pages.

In alignment with the level of performance and expressions of frustration, Participant 15 reported the perceived difficulty of Scenario 3 as somewhere between "reasonably challenging" and "frustratingly difficult." She expressed readiness for fully online learning using a tablet device, stating confidently, that she would increase her digital competencies "by doing." Finally, she reported being most comfortable when using email, and least comfortable searching for bibliographic information on the tablet. This was consistent her reported competencies, which included a low score of 15 for GTCU-I Item 20, related to searching for books online, and a high score of 30 for GTCU-S Item 11, related to using email to communicate.

5.3.6 Consolidating insights from video case studies

By exploring the details of Scenario 3 performances, interviews and related field notes, a much richer picture of participant activities emerged beyond what could be gleaned from performance scores alone. These case studies facilitated the identification of several performance influencers beyond the purview of the GTCU, including: (a) task difficulty; (b) general comfort with the mobile device; (c) observed levels of participant engagement, comfort, patience, persistence, frustration and fatigue; and (d) task comprehension, and completion strategy. Each of these variables represent facets of the immediate situation shaping the quality of performance processes and outcomes.

In some cases, these additional facets of performance, such as the frustration experienced by Participant 15 and the recurring expressions of fatigue marking Participants 14's effort, most clearly impacted overall performance negatively, despite high reported competencies. In other cases, such facets—for example the calm determination of Participant 9—elevated the level of performance, but also led to a lengthier overall completion time of 57 minutes. Completing the same scenario in only 22 minutes with a well synchronized touch and elegant operational style developed through significant home use, Participant 7, nevertheless, couldn't maintain the same high quality of task outcomes. Here, the issue of a participant's personal educational values (motivational orientation) comes to the fore. Is a learner most interested in achieving efficient completion of an instigated activity (a posture weighted toward leveraging extrinsic motivation), or does one take on the activity as their own, enjoying the challenge and ensuring the highest quality outcomes (a posture weighted towards integration and intrinsic motivation)? A third response is reflected by Participant 11, who adopted a somewhat *amotivated* orientation (Deci & Ryan, 2000) to performance, resulting in several task comprehension problems that had little to do with level of digital competencies, but which negatively impacted her scores.

5.4 Research Question 4: Interpreting the Data in Relation to Readiness

RQ4. Can the GTCU be used as an effective instrument for the initial probing of digital-learning readiness? Do meaningful patterns, related to general readiness, emerge between reported GTCU competency scores and assessed performance on authentic digital-learning activities?

Significant relationships were found between reported digital competencies and the quality of performance of authentic digital-learning activities. In addition, by means of five case studies, additional situational and psychological variables—not measured by the GTCU instrument but influencing the overall quality of human performance in digital-learning contexts—have been explored. The remaining challenge is interpret the findings in relation to the readiness-for-digital-learning construct with which this study began.

5.4.1 First considerations

To address the question whether the GTCU can be used as an effective instrument for the initial probing of digital-learning readiness, the following considerations are highlighted:

1. As demonstrated through a literature review, digital competencies are a key complex of variables, widely recognized as tremendously influential factors in relation to digital-learning readiness.
2. Digital learning takes on many forms (Aparicio et al., 2016; Siemens et al., 2015), and even when a target model is well conceptualized and consistently implemented in a particular context of higher education, it is overly ambitious (and from a learning perspective, probably misguided) to propose a single “ideal” digital-competency profile for digital-learning readiness. Indeed, this study presents observational data suggesting that effective digital learning may be realized by a variety of individuals with substantial variation in their reported general digital competencies.
3. With respect to this study, it is conceded that the small sample size, and participant selection bias (leading to a participant pool that generally, but not exclusively, reported competencies well above the GTCU average for scenario-aligned items), limits our ability to explore a wide spectrum of readiness. However, if the performance scenarios designed for this study are accepted, as argued above, as reasonably authentic and relatively generic research activities, routinely conducted by students and teachers in contexts of higher education, this study may begin to address the potential of the GTCU instrument for probing digital readiness.

4. The GTCU's potential as a readiness tool emerges when we note the reported competencies and coded performances of the participants at both ends of the graph shown in Figure 10. This graph includes all 15 participants in this study, along with their reported competencies in blue (scored out of 180 but adjusted to base 36 for visualization purposes), and their performance scores in orange (also scored out of 36). Participants are sorted by GTCU scores (reported competencies). At the far left, P1 reported the highest digital competency, and achieved a perfect performance score. At the far right, P4 reported the lowest digital competency, and achieved the lowest performance score. Although each participant performed a different scenario, they are both males in their early 40s. (The Excel-generated, trend line is that of the performance scores, which, as found above through correlational analysis, statistically follows reported competencies.)

Figure 10: Reported GTCU Scores and Performance Scores Trend

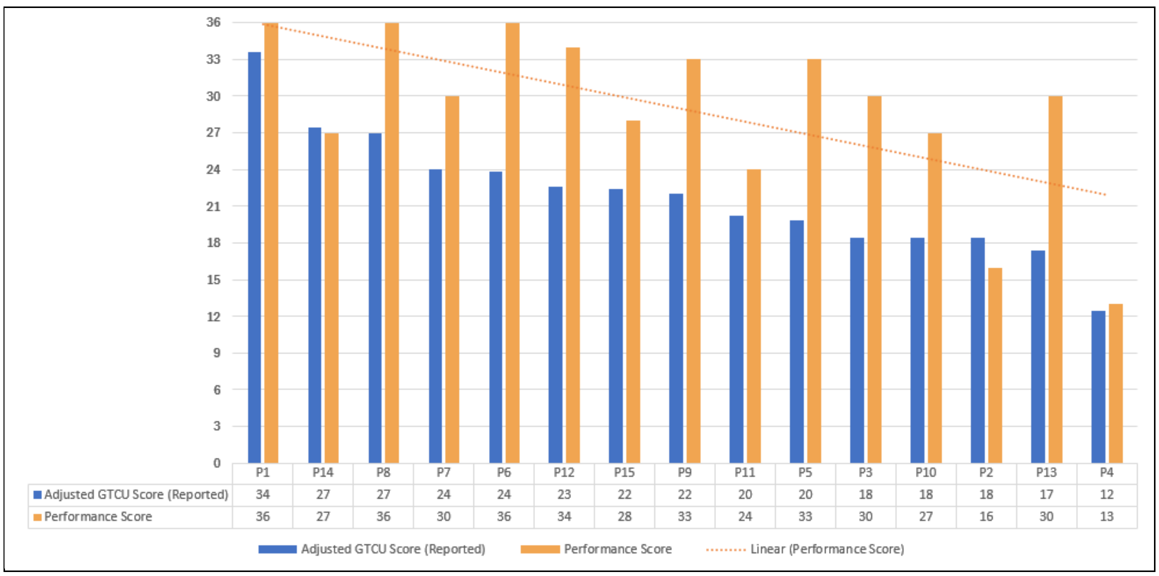


Figure 10 displays the: (a) high level of correspondence between GTCU and scenario performance scores at the high (left) and low (right) ends; and (b) general correspondence between reported competency and performance quality throughout the sample. We now look deeper into the coded performances of P1 and P4, and interpret these performances in relation to general readiness for online learning. Simply put, the logic is that we have substantial evidence of alignment between what these two individuals said they could do, and what they demonstrated they could do. The current question is to what degree their performance is suggestive of the ability to achieve full functioning in contexts of *digital learning*, understood throughout this study, as an umbrella term inclusive of online, distance and blended learning (Siemens et al., 2015), and incorporating related practices such as mobile learning (Alhassan, 2016; Crompton et al., 2016; Shroff et al., 2015; Soykan & Uzunboylu, 2015; Viberg & Grönlund, 2015), with specific activities shaped by context, socio-political values, epistemologies and learning models (Aparicio et al., 2016).

5.4.2 Readiness at the high and low ends

Beginning at the low end, as shown in the coded activity timeline presented in Figure 11, Participant 4 (with an adjusted reported competency of 12, and a performance score of 13) failed to complete the first task of Scenario 2 (Appendix E), related to generating and sharing directions from a Canadian airport to a conference venue—even after 50 minutes. This activity was rated 12.6 (see Appendix D), and thus, had a low expected difficulty. In fact, it was strategically positioned by this researcher at the start of the scenario as a "warm-up" to an otherwise challenging scenario.

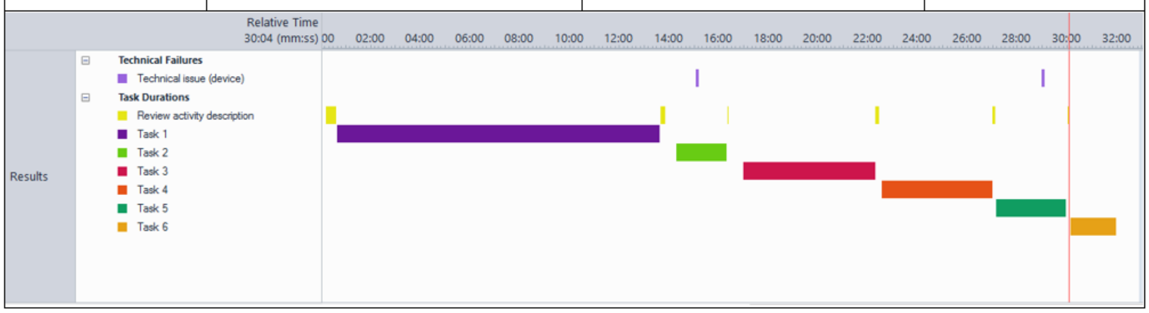
Figure 11: Coded Performance Timeline of P4 (Participant with Lowest Reported Competency)

This individual appeared extremely hesitant and more focused on exploring the affordances than pursuing strategies for task completion. Although expressive signs of frustration were largely absent, lengthy recurring pauses in device interaction, facial expressions of uncertainty, and recurring navigational and input problems were observed. In short, the participant looked unsettled and somewhat lost. He appeared to adopt a posture of resignation rather than allow himself to be frustrated by the challenges of specific tasks. During his post-activity interview, he reported that "technology is not enhancing my learning—it's hindering it." Consistent with this sentiment, he also reported being comfortable only during those brief moments when he was viewing "a familiar web page." He was least comfortable when he "couldn't find out how to do something," which appeared to be his predicament for most of the 50 minutes.

The performance of Participant 4 stands in stark contrast to that of Participant 1 (Figure 12 above)—the individual with the highest self-reported competency in this study (an adjusted score of 34, and a performance score of 36). Although P1 lacked the ultra-smooth operational style displayed by other participants (e.g., P7), he exhibited consistent confidence and strategic purpose, completing all tasks with a high level of quality, despite initial moments of apparent nervousness, reminding us that success is sometimes a psychological struggle, particularly with cameras rolling. In fact, during execution of Task 1, it took this participant 13 minutes to export a journal reference in the required APA format. This was almost four minutes above the average. P12 completed the same task correctly in under 5 minutes. Yet, after this inauspicious start (or, perhaps because it) he quickly settled his nerves, gained confidence and direction, and completed the remaining tasks with both precision and efficiency.

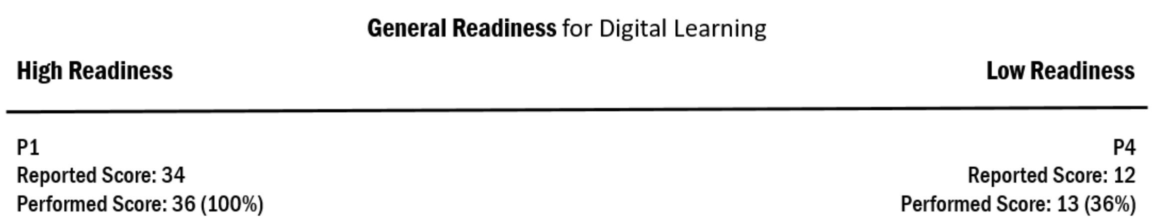
Figure 12: Coded Performance Timeline of P1 (Participant with Highest Reported Competency)

P1: Male, Age 40	Adj. Reported Competency: 34	Performance Score: 36 (100%)	Total Time: 32 min



Therefore, at the high and the low end of our participant list, tremendous differences were both reported and observed. Moreover, because both general comfort and the ability to complete educational tasks effectively with digital devices are essential in digital-learning environments, it is quite defensible to position these individuals at the opposite ends of a general readiness (for online learning) spectrum as presented in Figure 13.

Figure 13: P1 and P4 Positioned on a Readiness Spectrum



Having positioned the two participants with the highest and lowest, reported and performed, digital competencies on this hypothetical readiness spectrum, we turn attention to the middle participants. These participants are presented in Table 8 below, sorted by adjusted reported total (ART) competency score, which, as shown in column four, ranges from 27 (seven points below the P1) to 17 (5 points above P4) on a 36-point scale. What patterns can be detected in this middle region, and how might these patterns be interpreted in relation to positioning participants on the readiness spectrum? Once positioned, what can we say about the GTCU instruments general ability to function as a readiness probe?

5.4.3 Readiness in the middle

At the group-level, the general pattern of correspondence between reported competencies and performance is established. At the individual level, focusing on differentials between reported competencies and performance scores (Table 9, Column 7), a consistent pattern of lower, sub-7 differentials emerge among the middle participants from highest to lowest reported competencies (P14:0; P7:6; P15:6; P11:4; P2:2). Moreover, where there are more pronounced differentials (P8:9; P6:12; P12:11; P9:11; P5:13; P3:12; P13:13) the performance score always exceeds the reported competency score.

Table 9

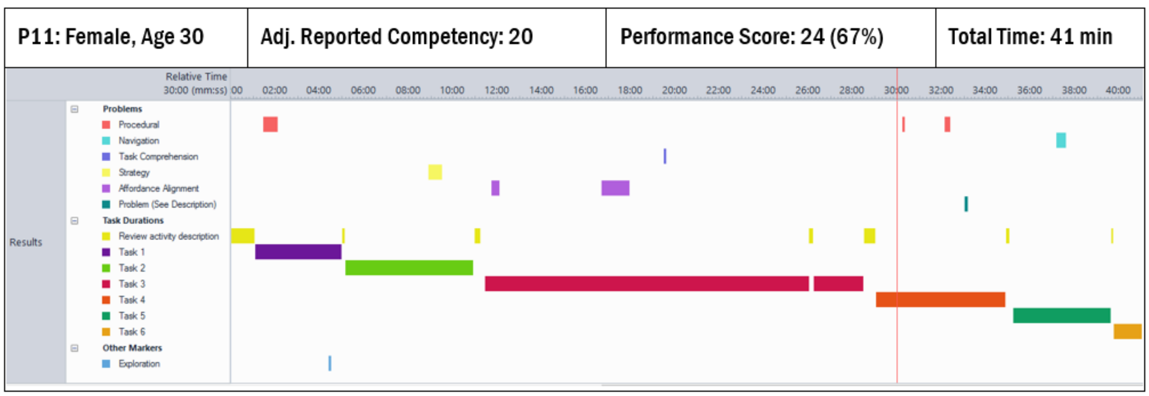
Exploring Readiness in the Middle: Participants Sorted by GTCU Score

Participant #	Gender	Age	Adjusted Reported Total (ART)	Performance Total Score (PT)	Performance Score as %	Differential Between ART and PT	Scenario Performed	Scenario Difficulty Ranking	Total Time on Scenario
P1	M	40	34	36	100	2	1	Med	32
P14	F	22	27	27	75	**0**	3	High	50
P8	F	34	27	36	100	9	1	Med	39
P7	F	23	24	30	83	**6**	3	High	22
P6	F	23	24	36	100	12	1	Med	29
P12	F	24	23	34	94	11	1	Med	23
P15	F	51	22	28	78	**6**	3	High	42
P9	M	22	22	33	92	11	3	High	57
P11	**F**	**30**	**20**	**24**	**67**	**4**	**3**	**High**	**41**
P5	F	22	20	33	92	13	2	High	29
P3	M	26	18	30	83	12	1	Med	49
P10	F	22	18	27	75	9	2	High	50
P2	**F**	**24**	**18**	**16**	**44**	**2**	**2**	**High**	**50**
P13	F	46	17	30	83	13	1	Med	40
P4	M	41	12	13	36	**1**	2	High	50

In fact, this is true for the entire sample. For those participants in the middle, the GTCU appears to facilitate underestimation rather than the overestimation of one's general readiness. This is a significant observation, requiring further study, because overestimation is a noted problem in the digital-competency measurement (Hargittai & Shafer, 2006; A.J.A.M. Van Deursen et al., 2014).

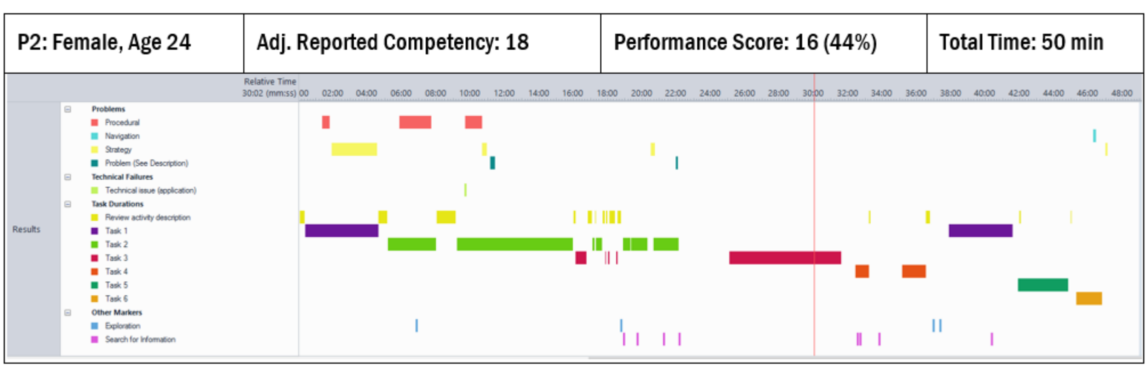
Based on the performance scores of the middle participants (see Table 8, Column 6, where the performance score is presented as a percentage score), 70% might reasonably be explored as a working "at risk" threshold for readiness. Two participants (P11:67%; P2:44%), who performed scenarios of high potential difficulty (#2 and #3), fall below this threshold. Analysis of P11's recorded performance timeline (Figure 14) revealed slightly awkward device interaction, a number of performance problems, but a generally well-structured approach to task completion (Figure 14). A significant barrier to greater performance quality related to the observed level of engagement and motivation, as noted in the case-study analysis reported above.

Figure 14: Coded Performance Timeline of P11



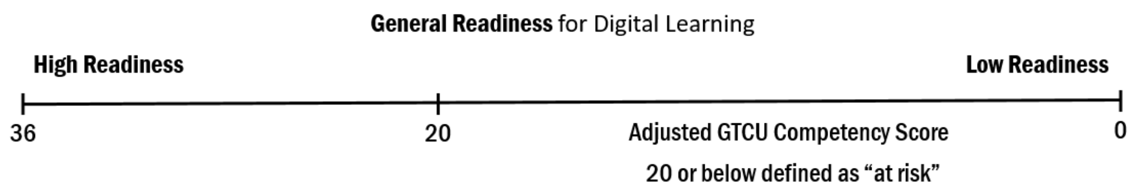
Participant 2's coded performance timeline (Figure 15 below) shows far more starts and stops during task activity, less overall performance structure, and more exploration and information-search activity that P11's timeline.

Figure 15: Coded Performance Timeline of P2



After performing Scenario 2, she reported more comfort with social than research tasks, and this aligned with her reported primary uses of the smartphone for social interaction and a tablet for entertainment. Unlike P11's "disengaged" performance, P2's performance was characterized by a high degree of struggle. Despite this struggle, her attitude remained generally positive. She reported that "the activity was great because it was so hard." Based on these timelines and accompanying observations, both of these performances present some cause for concern in relation to general readiness for digital learning. As such, they provide us with a body of data to propose a readiness threshold. Working from Participant 11's reported competency score, 20 appears to function well as a boundary below which individuals might be considered "at risk" in relation to optimal functioning in digital rich learning contexts (Figure 16). All participants above this proposed threshold achieved a performance score of 75% or better. Moreover, two of six participants at or below this threshold showed significant signs of struggle. Such is the nature of general readiness assessment. If the levels of general digital competency, as reported by the GTCU, can reliably follow the general performance trends of student groups, it is expected that thresholds can be established and interventions (such as self-assessment performance activities) can be prescribed to those following below the threshold. The expectation would be that many of these individuals would perform well, but some would benefit from intensive encouragement and support, particularly at the early stages of a digital learning experience.

Figure 16: A Proposed Readiness Threshold



This proposed readiness threshold may not be applicable to other contexts of higher education and digital-learning. Indeed, as presented, the empirical bases for this proposal was developed through exploratory, mixed-methods analyses of a small and selective sample at UOIT, Canada using only three research activities. Nevertheless, this is the first formal body of data systematically comparing digital competencies, reported via the GTCU, to observed performance on authentic digital-learning activities. Therefore, it provides a modest first step in moving beyond an expert-profile approach to relating GTCU reported competencies to "real-world," digital-learning performance.

6 Discussion

6.1 Reviewing the research strategy

This study sought to explore a number of related conceptual and techno-methodological avenues to address a gap in the readiness-for-digital-learning research. It has followed, what some might characterize, as rather circuitous path. Yet, in following (or more accurately, constructing) this path, this research has sought to provide ample bridges and sign posts so as to orient the reader to what are considered the most pressing matters at hand. Before venturing further afield to discuss the findings, a summary of our journey, produced in hindsight, is provided.

Placed within the context of digital learning in higher education, and international research on micro-level (participant) readiness—in which digital competencies are widely recognized as highly influential factors—this study leveraged conceptual and operational apparatuses from the parallel field of digital abilities research. An instrument, representing an operationalization of the General Technology Competency and Use framework, was selected as a potentially useful tool for probing student readiness because it offered a richly categorized approach to digital competency, which grouped digital interactions both by type and devices used. Moreover, it united behavioural and attitudinal indicators—(a) general frequency of past interactions, and (b) interaction-related confidence—as twin, synergistic measures. This instrument, and the conceptual foundation on which it is built, therefore, was conjectured to possess a measurement capability beyond that of most instruments currently used in readiness research, which are characterized by inconsistent use of behavioural and attitudinal indicators, and a general conceptualization of digital competency as a unidimensional construct.

Yet, in seeking to strengthen micro-level, digital-readiness research by importing an instrument from a parallel field, new problems were introduced. The GTCU was developed through extensive theorization and application in international contexts of digital learning in higher education, but it was never grounded on systematic analyses of performance processes and outcomes. GTCU researchers could, and did, report measured levels of frequency and confidence, of students and teachers, for a variety of specific activities and devices, ordered by dimension of interaction. However, this was primarily a descriptive and self-referential exercise. A methodology had not been developed to *relate* reported levels of competency to an empirically grounded conception of optimal functioning in digital-learning contexts. Therefore, use of the GTCU instrument as an effective tool for probing general readiness remained limited.

To address this gap, the immediate operational challenge was one of designing performance activities that could be validated as facilitating authentic digital-learning processes and outcomes. A performance activity design model was developed through conceptual analysis of existing digital-competency performance-observation methodologies, and a consideration of EILAB affordances for the high-fidelity, multi-perspective, audio-visual recording of real-time, human-computer interaction. In the end, after significant pilot testing and technological optimization, three scenarios, aligned with Herrington's guidelines (and a general, social-scientific learning context), were designed by this author with constituent tasks (six tasks per scenario) mapped to specific GTCU indicators from three dimensions of interaction: social, information and epistemological. Tablets were selected as activity devices owing to the increasing role of mobile technology in education, and the call from several digital competency researchers to address the device gap in performance analysis. A cutting-edge, scientific, video-analysis application (Noldus The Observer XT 13) was selected for reviewing synchronized video and coding performance processes, with due attention given to quality of task completion, overall level of comfort and engagement, several types of performance problems (e.g., navigation and touch input), psycho-physiological inhibitors (frustration and fatigue), task completion quality, and scenario performance times.

The qualitative analysis was reduced to a process-quality score for each task, and combined with an outcomes quality score for each task, to facilitate correlational analysis with levels of reported competencies. Reported competencies were calculated using a GTCU competency score calculated by combining both the reported levels of frequency and confidence for computers/laptops, smartphones and tablets—six items in total. This methodology was defended as a legitimate operational response to the: (a) conceptualization of frequency and confidence as twin, synergistic indicators; and (b) the recognition that the experience gained through engaging in a specific activity on one device (e.g., using Facebook) would likely benefit an individual while performing the same type of activity on a different device. (This expected transfer of experience was conceptualized in relation to the dual mission of interface designers to leverage the unique capabilities of a target device while maintaining continuity of user experience across devices. It was also related to the nature of today's web browser, which provides a relatively consistent container for web applications across devices and operating systems.)

The findings suggest that this methodology was reasonably well conceived. A consistent pattern of positive correlations was found between self-reported GTCU scores and the overall performance quality scores at the task and aggregate levels for the groups performing the first two scenarios. For those individuals performing the third scenario, a low positive correlation was found at the aggregate level, but several negative correlations were found at the task level. This led the researcher to dig deeper, producing case studies for the five participants in the Scenario 3 group. This included a "second-pass" review of each participant's video timeline, and consideration of field notes and recorded, post-activity interviews. These analyses revealed several influencers of performance beyond the purview of the GTCU, including: (a) task difficulty; (b) general comfort with the mobile device; (c) observed levels of participant engagement, comfort, persistence, frustration and fatigue; and (d) task completion strategy.

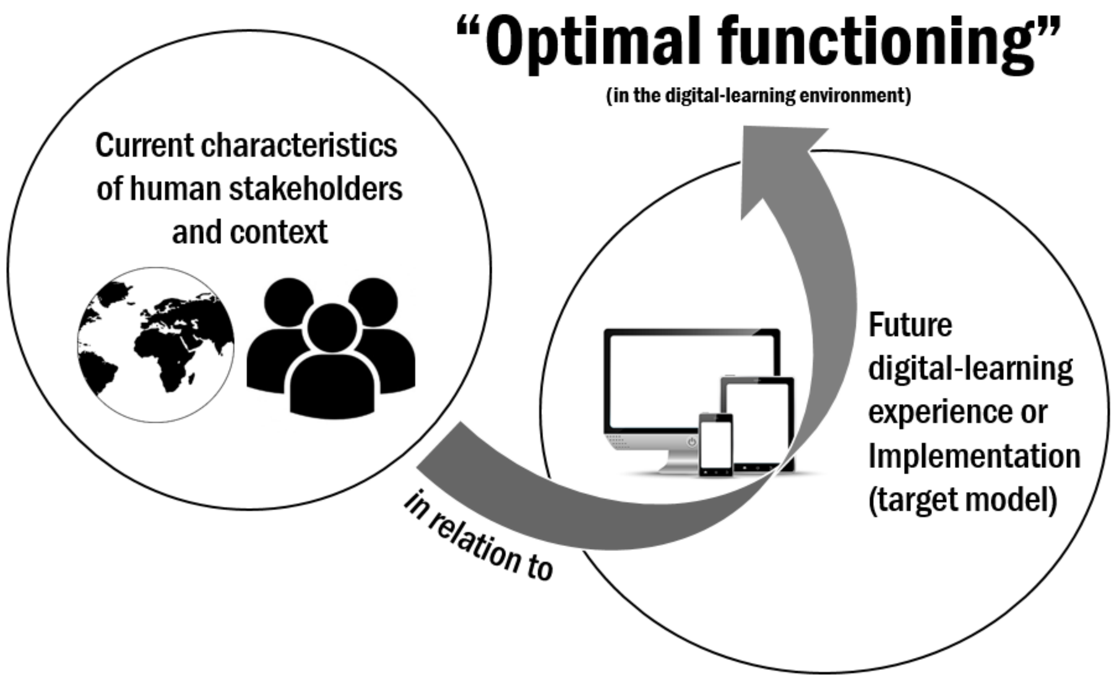
Finally, we addressed how the reported quantitative and qualitative findings could be interpreted to position the GTCU instrument as a tool for probing participant readiness for online learning. Based on the mixed-methods data set produced in this study, the individuals at the high and low ends of the participant pool were positioned on opposite ends of a hypothetical readiness spectrum. Through analysis of the middle participants, a threshold GTCU score was established as a tentative marker below which students “at risk” might be located. Two of six participants below this threshold failed to perform at a level that would suggest preparedness to achieve optimal functioning in a context of richly digital and mobile learning.

In the end, by means of empirical analyses of performance, which has been supported by the rich affordances of the EILAB, the GTCU instrument remains a viable general readiness instrument. That being said, it is important that we adequately address the conceptualization and contingent nature of readiness as optimal functioning, and the role of digital competencies in relation to such functioning.

6.2 Readiness as Optimal Functioning

Readiness has been described, in this study, in relation to “optimal functioning” in digitally rich contexts of learning in higher education. This is a process-centric construct that may only be operationalized, with some specificity, in particular educational contexts, and in relation to the guiding epistemologies, pedagogical or learning models, and particular arrays of technological affordances operating in these contexts. For example, in the context of fully-online learning in degree programs at the Faculty of Education, UOIT, Canada, “optimal functioning” is operationalized in relation to: (a) social constructivist learning; (b) the Fully Online Learning Community (FOLC) model (vanOostveen, DiGiuseppe, et al., 2016), which envisions effective learning primarily in relation to processes of democratized, communication and collaboration, and (c) a rich mix of digital tools and environments supporting both synchronous and asynchronous communication. Students and facilitators may be considered ready for effective learning, in this context, when they are able to achieve and maintain high levels of participation, motivation, and direction, and just as importantly, use and maintain the full, general capabilities of their enabling communication technologies (e.g., a microphone and a webcam for online group sessions).

Figure 17: Readiness for Digital Learning and "Optimal Functioning"



Viewing readiness for online learning in relation to contextually-defined, optimal functioning has several implications. First and foremost, this research rejects a "one-size-fits-all" definition of readiness. This certainly applies to the group-level, as noted. Keeping in mind the results of the process analyses conducted in this study, this must also apply to the individual level. Certainly, in relation to digital competencies, no particular profile, based on reported experience and attitudes of confidence, predicts successful functioning within the context of performing a complex learning activity. Rather, the best one can achieve, after learning activities have been carefully mapped to specific self-report indicators, is the creation of a general readiness threshold under which some might be expected to struggle without aid, for example, from fellow learners or technical support staff.

Second, a process-centric approach to optimal functioning calls into question the assumed usefulness of using course grades as a measure of success in digital-learning environments. Grades may become increasingly important to the extent that they are built on a theoretical foundation of authentic assessment, which allows for significant variability in the procedures and goals adopted by learners to address course activities. Finally, optimal functioning draws attention to digital competencies as a key readiness complex and to those other "critical-success" factors addressed only tangentially in this study, such as motivation, engagement, psychological and physiological comfort, level of frustration and anxiety, self-regulation and persistence.

In the end, this study provides little to those who seek to screen applicants based on some preconceived profile of learner success. In fact, it calls such an enterprise into question.

6.3 Future Development of the GTCU

It is noteworthy that combining an individual's frequency and confidence values across three devices (for each GTCU activity), which is fully consistent with the GTCU's theorization, facilitated a manageable and meaningful way to relate self-report data to performance scores. It also provided a means to develop a threshold-based approach to detecting a segment potentially containing learners at risk of falling below those abilities required for optional functioning. Considered alongside the results of mixed-methods analyses of middle-ranking participants (which showed that lower reported general competencies could lead to good levels of performance), it is time to move beyond constructing ideal target profiles mapped to the major conceptual dimensions of the GTCU as a way to conceptualize readiness. This runs the risk of assuming far too much alignment between self-reported competencies and effective performance. Additionally, it tends to read too much into GTCU's theorization of digital competencies. The various orders of use provide a useful typology for grouping self-report indicators and mapping them to aligned tasks. One must be careful, however, to avoid using any particular indicators as a proxy for an entire dimension of competency. To suggest, for example, that someone is strong on the informational dimension based on a GTCU score, may have little to do with their ability, when given the opportunity, to perform an authentic, complex, and inevitably multi-dimensional research task in which a specific type of information, must be found, critically assessed, analysed statistically, converted to a particular file format, and shared on a social network.

6.4 Limitations

As an exploratory, mixed-methods study bridging multiple domains of research, several limitations must be recognized. These have been divided below into conceptual and methodological imitations.

6.4.1 Conceptual

In this study, digital competency has been, to a large degree, conceptualized and measured as an individual-level construct. For example, performance activities were conducted alone without the direct input of others. Moreover, readiness for online learning has been primarily addressed at the individual level. Ultimately, digital-competency research conducted explicitly at the group level should be incorporated into our conceptualizations of readiness for digital learning. This is especially vital in contexts where social-constructivist theories and values are used to guide the educational experience.

Although focusing on digital competency as a readiness factor was defended through an in-depth literature review, it is apparent, from the subsequent case-study analyses, that several psycho-physiological constructs (e.g., motivation, engagement, determination, anxiety, fatigue, self-regulation, etc.) influence optimal functioning in contexts of digital learning. This is a second limitation. A fuller approach to digital readiness instrument development must address additional dimensions, a greater mix of indicators, and explore additional sets of correlations between self-reports and performance.

6.4.2 Methodological

There are several methodological limitations to note. First, the sample was limited to fifteen students drawn primarily from a single departmental context at a Canadian technological university. Moreover, by comparing the reported GTCU scores of this sample with average scores from the full GTCU database of almost 700 individuals (comprised mostly of university students, but from a diversity of institutions and national contexts), this sample appears positioned well above the average level of reported competency. Fortunately, this sample provided a diversity of reported competencies and performance scores to explore correlations and develop a set of methodological procedures that can be pursued with larger samples in different contexts. It also provided one participant drawn from an important segment of students, which struggle to use digital technologies effectively for learning.

Second, the coding scheme developed for qualitative analysis of performance processes could be improved. For example, the Problem codes were implemented in The Observer XT as durational markers, but often it wasn't always clear when a problem ended. It became apparent that, for this study, it was sufficient to note that a certain type of problem event occurred, and thus, point event markers would have sufficed. Additionally, it wasn't always easy to differentiate between specific types of problems. That is, there was a degree of dimensional overlap, for example, between a Navigational problem, a Procedural problem and a Task Strategy problem. This coding scheme might be refined by leveraging typologies developed in the domains of human-computer interaction and software usability, for example.

Third, inter-rater reliability procedures were not implemented in this study. This was owing to an aggressive timeframe guiding this research, and the judgement that as a small-sample, exploratory study, modest benefit would be gained by introducing another layer of analytical procedures. Indeed, some related methodological work of digital-learning researchers highlight the difficulty of achieving high levels of inter-rater reliability when coding learning interactions without implementing negotiation procedures (Garrison, Cleveland-Innes, Koole, & Kappelman, 2006; Rourke & Anderson, 2004; Rourke, Anderson, Garrison, & Archer, 2001).

Following this path would have added a significant additional layer of analytical processes, and seriously jeopardized the timeframe.

Finally, two limitations can be noted in relation to the scenarios and performance sessions used in this study. The first, related to the dependent nature of three tasks in Scenario 2. These task dependences made it difficult for participants to achieve high performance scores in the second and third tasks in the sequence if they struggled with the first. Additionally, owing to the scheduling of some back-to-back sessions, artefacts from a previous participant were discovered, and in one case used, to improve the results of a subsequent participant. These two limitations were mitigated somewhat by a scoring procedure which sought to treat each task as a distinct performance act. For example, if a participant was able to download data in Task A, used as the basis for a chart in Task B, they could make up data to produce the chart, and still achieve a perfect score for Task B. Similarly, existing artefacts were considered fair game as long as they were used to guide a set of required procedures rather than circumvent them. In fact, the latter did not happen in this participant pool, even though, on one occasion, a participant paused, and appeared tempted to accept a shortcut.

6.5 Research Opportunities

Several additional research opportunities present themselves. Of course, the general techno-methodological procedures introduced in this study could be refined. Moreover, by pursuing larger-sample performance studies in a diversity of contexts, and exploring digital competencies in relation to a variety of digital-learning models) the proposed threshold-approach to readiness could be tremendously improved.

Two more specific opportunities also present themselves. The first relates to exploring relationships between machine-parsed, emotional expressions, and human-computer interaction. In fact, the observational setting, device positioning, level of recording quality and positioning of the camera (capturing the participants' faces) in this study, had been carefully optimized for just such an analysis using Noldus FaceReader 7. Unfortunately, it was decided that introducing another level of data would unnecessarily complicate a study that had already injected several layers of conceptualization and analysis. However, having repeatedly observed the value of facial expressions as a frame for interpreting human-computer interaction, this research sees great value in exploring how this layer of data might expose meaningful patterns of emotional responses, and facilitate a richer description of performance. Would the machine reliably detect the frustration exhibited by Participant 15, the repeated yawns of Participant 14, or the smiles of satisfaction that routinely accompanied the successful task completion of Participant 9? What patterns of subtle emotional response would be revealed that completely escaped the purview of this researcher?

The second opportunity relates to the exploration of digital readiness across cultures. Importantly, several researchers addressing readiness at the macro-level of analysis identified culture as representing sets of variables influencing patters of technology adoption and effective use in technology-rich learning contexts (Ilgaz & Gülbahar, 2015; Islam et al., 2015; Mosa et al., 2016; Rohayani et al., 2015). Moving beyond this, how do cultural values (e.g., at the level of nation, region or organization) shape the three dimensions of readiness at the micro level (i.e., human characteristics, target learning model, and "optimal functioning"), and to what degree are patterns of reported competencies and performance related to values influencing technology use and perceptions of effective learning?

6.6 Conclusion

6.6.1 Summary

A detailed review of this study was provided in 6.1 above. In miniature, this study, addressed gaps in the research by exploring an instrument from the domain of digital-competency research. With a specific interest in higher education, the GTCU instrument was selected as a potentially viable tool for scoping participant readiness for successful functioning in contexts of digital learning, understood as a general milieu. A mixed-methodology was forged, combining exploratory statistical analyses of performance scores, and qualitative, audio-video, case-studies of participant interactions while performing an authentic activity with a mobile device (RQ1).

A consistent pattern of positive correlations was found between self-reported GTCU scores and the overall performance quality scores at the task and aggregate levels (RQ2). Case-study analyses revealed several influencers of performance beyond the purview of the GTCU, including: (a) task difficulty; (b) general comfort with the mobile device; (c) observed levels of participant engagement, frustration and fatigue; and (d) persistence and task completion strategy (RQ3). Most importantly, the GTCU instrument supported a threshold-based approach to identifying learners "at risk," defined as those not prepared to achieve optimal functioning in a higher-education context of digital learning (RQ4).

6.6.2 Major contributions to research

This exploratory, techno-methodological study of readiness for digital learning made several contributions to research:

1. Based on an extensive, synthetic review of the international, readiness-for-digital-learning literature, it presented a structural model of the readiness concept, and identified major gaps in existing research largely caused by scant interaction between

readiness researchers, on the one hand, and digital-competency specialists, on the other hand.

2. It offered a generic, conceptual model for activity design and performance observation, derived through extensive methodological analysis and pilot testing, potentially relevant to other research contexts.
3. It highlighted the potential of a validated, general digital-competency measurement instrument—the GTCU Profile Tool (Desjardins, 2005; Desjardins et al., 2015; Desjardins et al., 2001)—for probing readiness. Moreover, within the defined research context, it demonstrated the GTCU Profile Tool's ability to separate high and low performers, and also, identify groups of individuals in the middle who may struggle as digital learners.
4. It offered a strong conceptual rationale (and specific procedures) for generating a single reported (GTCU) score by combining frequency and confidence items across three device categories. This addressed the problem of how to interpret the numerous data points of the GTCU in relation to readiness, and compare reported competencies to performance scores.
5. It piloted case-study procedures for identifying more and less successful digital-learning performances by: (a) leveraging high-definition, multi-perspective, audio-visual recordings of learner-device interactions during authentic digital-learning activities; and (b) coding and visualizing performance problems, strategic disjunctions, and psycho-physiological on an activity timeline.
6. It introduced tablet devices as the basis for performance activity, responding to the call of researchers to explore digital-learning performance beyond desktops and laptops (Litt, 2013).
7. It articulated a conceptual orientation of digital-learning readiness that is process-centric and focused on optimal/successful functioning (and authentic artifacts) rather than formal course outcomes such as marks. This articulation is especially well aligned with process-centric, digital-learning models such as Fully Online Learning Community model (Blayone, vanOostveen, et al., 2017; vanOostveen, DiGiuseppe, et al., 2016) and the Community of Inquiry framework (Garrison, 2011, 2013).
8. Finally, it encouraged the ongoing development and use of the GTCU Profile Tool data set for correlational studies seeking to address facets of technology use and digital empowerment in a variety of contexts.

Beyond improving and consolidating the GTCU as a readiness tool, future research concerns, extending from this study, include leveraging digital competencies and innovative forms of social-constructivist learning to build empowerment (Perkins, 2010; Perkins & Zimmerman, 1995; M. A. Zimmerman, 1995) and imagined possibility (K. P. Brown, 2016) in contexts of social-economic transition, with a special focus on post-Soviet environments. Therefore, the GTCU instrument will remain an indispensable part of this researcher's toolkit for some time to come, as focus will be given to exploring the role of democratized, social-constructivist, digital learning for human flourishing and educational transformation.

7 Appendices

7.1 Appendix A: Participant Invitation

You are invited! Help explore the future of learning by participating...

...in a mobile competencies research study in the EILAB, UOIT's digital-learning observatory at the Faculty of Education, UOIT (11 Simcoe St., downtown). Participants engage in a short survey online, and a research activity (on a new Apple or Samsung device), and a post-activity conversation in the EILAB. Participation takes about 60 minutes. You may also tour the EILAB, and enter to **win a Samsung Galaxy tablet**. **To schedule a convenient time**, please send an email to Todd Blayone, Researcher, at todd.blayone@gmail.com, with subject line "EILAB MOBILE STUDY." Don't delay!

Participation is voluntary and you are free to decline without explanation or consequence. By consenting to participate in this research, **participants do not waive any legal rights**. There are no potential risks to you in participating in this study. **You have the option to withdraw without penalty or prejudice at any time**. Withdrawal of person and data may be accomplished, without reason or consequence, during or after participation in the study by notifying Todd Blayone in person (during a session) or by email to todd.blayone@gmail.com with subject line "Data Withdrawal Request." Any data you have provided up to that point will be deleted. **The entire research dataset will always remain anonymous and confidential outside the research group.** Unless a withdrawal request has been received, the dataset will be stored in digital form and secured by password-protected encryption on computer hard drives at UOIT. The dataset may be used for secondary analysis in future studies of a similar type, for example, to compare with datasets of a similar type. The results of primary and secondary studies will be for research only, and may be shared with the scientific community through publications and conference presentations. *With respect to survey data collection, although SurveyMonkey uses US servers, and is subject to US laws and/or the Patriot Act, NO personal or identifiable information is collected in the survey and all data are deleted from SurveyMonkey immediately after the collection period.* This study has been approved by the UOIT Research Ethics Board REB #13-082 on April 16, 2016. If you have any questions concerning the research study or experience any discomfort related to the study, please contact the researcher Todd Blayone at todd.blayone@gmail.com. Any questions regarding your rights as a participant, complaints or adverse events may be addressed to Research Ethics Board through the Ethics and Compliance Officer – researchethics@uoit.ca or 905.721.8668 x. 3693.

Researcher	Supervisor
Todd Blayone, MA Researcher EILAB, Faculty of Education, UOIT http://eilab.ca/todd.blayone	Dr. Roland van Oostveen EILAB, Faculty of Education, UOIT http://eilab.ca/roland.vanoostveen

7.2 Appendix B: GTCU Self-Report Instrument

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GTCU Custom Survey 2016-17 | EILAB | Study 1

1. Ethical Compliance Information

This study explores relationships between self-reported technology abilities and activity on a mobile device. Please complete all survey questions and the accompanying activity.

Voluntary Participation, Withdrawal, Confidentiality

- Participation is voluntary and you are free to decline without explanation or consequence. By consenting to participate in this research, participants do not waive any legal rights.
- You have the option to withdraw without penalty or prejudice at any time. Withdrawal of person and data may be accomplished, without reason or consequence, during or after participation in the study by notifying the Researcher, Todd Blayone, in person (during a session) or by email to todd.blayone@gmail.com with subject line “Data Withdrawal Request.” Any data you have provided up to that point will be deleted.
- The entire research dataset will always remain anonymous and confidential outside the research group. Unless a withdrawal request has been received, the dataset will be stored in digital form and secured by password-protected encryption on computer hard drives at UOIT. The dataset may be used for secondary analysis in future studies of a similar type, for example, to compare with datasets of a similar type. The results of primary and secondary studies will be for research only, and may be shared with the scientific community through publications and conference presentations.
- There are no potential risks to you in participating in this study.
- With respect to survey data collection, although SurveyMonkey uses US servers, and is subject to US laws and/or the Patriot Act, NO personal or identifiable information is collected in the survey and all data are deleted from SurveyMonkey immediately after the collection period.

Ethical Compliance, and Contact Information

- Given these safeguards, this research has been reviewed and approved by the Research Ethics Board of UOIT as well as UOIT’s Ethics and Compliance Officer. The REB number assigned by UOIT is 13-082.
- If you have questions regarding this study, please email Todd Blayone: todd.blayone@gmail.com.
- Concerns about the ethics may be addressed to UOIT Ethics and Compliance Officer (905) 721-8668 (Ext. 3693) or compliance@uoit.ca.

By clicking the "Next" button, and having read and understood this notice of information and consent:

- I freely consent to participate in this research.
- I have read this notice of information and consent, and had all questions answered to my satisfaction.
- I understand participation is voluntary, and I am free to withdraw at any time without consequence.
- I understand that data I provide for the study will be housed on a secure UOIT server, analyzed by the researchers only, may be used for secondary analysis in future studies, and reported on in research presentations/publications.
- I understand that my data will remain anonymous and confidential outside the research group.

"Next" to continue. To end participation, "Exit the Survey" at top.

EILAB

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GTCU Custom Survey 2016-17 | EILAB | Study 1

3. Digital Device Access and Use

6. Please select what best represents your access to the listed digital technologies. Please ignore any item you do not use.

	I own at least one	Don't own, but access regularly
Desktop Computer	○	○
Laptop Computer	○	○
Smartphone	○	○
Tablet/iPad	○	○
Wearable (digital watch, health device, etc.)	○	○

7. How would you describe the primary and secondary purposes of the computers and digital devices which you own or use frequently? Please ignore devices that you do not own or use.

	Principle Use	Secondary Use
Computer Desktop		
Computer Laptop		
Smartphone		
Tablet		

○ Bachelor's ○ Master's ○ Doctorate ○ Other

5. What is your current faculty, program, and area(s) of specialization:

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4. Frequency and Confidence of Activity with a Device (Social)

For each of the devices and the type of use listed below, please indicate your frequency of use and your confidence in the use.

8. To communicate with others using text messaging (SMS, Facebook Messenger, etc.)

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

9. To communicate with others using audio (e.g., phone, Skype, Viber, etc.)

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

10. To communicate with others using video (e.g., Skype, Google Hangouts, Adobe Connect, etc.)

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

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5. Frequency and Confidence of Activity with a Device (Social, Page 2)

11. To communicate with others using email:

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

12. To use online social-networking systems (e.g., Facebook, Twitter, LinkedIn, etc.):

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

13. To use an online data/document sharing platform for collaboration (Google Apps, Dropbox, Office Online, etc.)

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

14. To share my own ideas online with my network or the public (using blog, photo or video sites, social media, etc.)

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

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6. Frequency and Confidence of Activity with a Device (Informational)

15. To access digital maps online (e.g., MapQuest, GoogleMaps) or use GPS to find my way or to get directions:

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

16. To search and access journal and/or news articles online:

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

17. To search and watch video online (e.g., YouTube):

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

GTCU Custom Survey 2016-17 | EILAB | Study 1

7. Frequency and Confidence of Activity with a Device (Informational, Page 2)

18. To search and access images, photos or infographics online:

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

19. To search, access and/or download music online:

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

20. To search and download books (e.g., PDF, ebooks, audio) or purchase printed books online:

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad/e-Reader		

21. To use an online application to collect and organize information automatically (e.g., Google News or Feedburner, RSS, Tweetdeck, social-media aggregators, etc.)

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad/e-Reader		

GTCU Custom Survey 2016-17 | EILAB | Study 1

8. Frequency and Confidence of Activity with a Device (Computational)

22. To use and share a calendar/personal agenda (e.g., Google Calendar, Outlook, etc.):

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

23. To generate concept maps (e.g, Cmap), mind maps (e.g., xMind) or flowcharts (e.g., Visio):

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

24. To create, modify and use conceptual diagrams, models or technical drawings:

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

25. To sort large amounts of data (e.g., in a spreadsheet, online application, database, etc.):

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

GTCU Custom Survey 2016-17 | EILAB | Study 1

9. Frequency and Confidence of Activity with a Device (Computational, Page 2)

26. To produce graphs and data visualizations automatically from numerical data:

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

27. To perform complex calculations (e.g., in a spreadsheet, statistics application, etc.)

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

28. To do some form of programming, coding, scripting or markup to automate processes:

	Frequency of use	Confidence of use
I use a Computer		
I use a Cell Phone or Smartphone		
I use a Tablet/Pad		

7.3 Appendix C: Participant Script

1. You will be presented with an activity, to be completed on a tablet, which will be recorded with the two cameras you see in the tripods.
2. The full activity can be made visible on the large screen by scrolling with the mouse *after* the recording starts. Please don't review the activity until I signal you to start by tapping on the glass of the observation room.
3. This activity was designed as an authentic and challenging scenario. Don't sweat it if you are unable to accomplish a task. We're exploring how individuals use and solve problems with mobile devices to perform academic activities, and we know tablets can be frustrating at times.
4. The activity has six tasks. You may choose to abandon a task that is not progressing at any time. The activity and constituent tasks are not timed, but I will stop the activity to conduct a short interview when the recording reaches 50 minutes.
5. You may download apps or access any legal service on the Internet relevant to completion of the activity using the account information with the activity description. Please avoid using personal logins and accounts.
6. We are recording audio. Please feel free to think out load, or express key decisions or frustrations. This will really help us interpret what we see.
7. Please try to avoid covering your face during the activity as much as possible because we will also use your facial expressions as data, and this may involve automated software analysis.
8. Please use the device as it currently sits in the stand, and try to keep the stand and chair in your selected start position because the cameras will be positioned accordingly.
9. You have the Internet at your disposal, but I will be unavailable to answer questions once the activity, and the recording, starts. I will interrupt only if I detect a technical failure or if you are still active when we reach 50 minutes.
10. Are there any questions? (Once questions have been answered…)
11. Please position yourself in a working position in the chair and a comfortable distance from the device, and I will perform a final calibration of the cameras. This should take only a moment. When the cameras are calibrated, I will start the recording, tap on the glass, and you may scroll down to read the activity and begin.
12. At the end of the activity (just signal when you are finished), or after 50 minutes, I will return to conduct a very short interview. Please have some fun. This is not a test.

7.4 Appendix D: GTCU Items: Usage, Competency Scores and Rankings

Items are sorted by number in Table A1, and by average competency score in Table A2. This score is calculated using frequency and confidence (with computer, smartphone and tablet) values from the full GTCU profile database. Showing the average level of competency reported for an item, it provides an indication of the item difficulty. For example, item 11 (email) is that which individuals, in the full GTCU database, generally report the greatest competency. Item 21 (programming) is that which individuals generally report the least.

Table A1: GTCU Instrument (S, I and E) Items Sorted by Number

	Item #	Rank	Item Description	Scenario	Avg. Score
SOCIAL - Rating: 78.3	**8**	3	To communicate with others using text messaging (SMS, Facebook Messenger, etc.).	2	16.4
	9	5	To communicate with others using audio (e.g., phone, Skype, Viber, etc.).	Not used.	14.7
	10	7	To communicate with others using video (e.g., Skype, Google Hangouts, Adobe Connect, etc.).	Not used.	12.6
	11	1	To communicate with others using email.	1,2,3	16.8
	12	2	To use online social-networking systems (e.g., Facebook, Twitter, LinkedIn, etc.).	1	16.5
	13	9	To use an online data/document sharing platform for collaboration (Google Apps, Dropbox, etc.).	2,3	11.9
	14	14	To share my own ideas online with my network or the public (using blog, photo or video sites, etc.).	3	8
INFORMATIONAL - Rating: 86.3	**15**	8	To access digital maps online (e.g., MapQuest, Google Maps) or use GPS to find my way or to get directions.	2	12.6
	16	6	To search and access journal and/or news articles online.	1	12.9
	17	4	To search and watch video online (e.g., YouTube).	1	15.4
	18	13	To search and access *images, photos or infographics* online. (Adjusted from *movies* for scenario).	3	9.7
	19	10	To search, access and/or download music online.	Not used.	11.5
	20	11	To search and download books (e.g., PDF, eBooks, audio) or purchase printed books online.	3	10.7
	21	20	To use an online application to collect and organize information automatically.	Not used.	5.6
EPISTEMOLOGICAL - Rating: 64	**22**	12	To use and share a calendar/personal agenda (e.g., Google Calendar, Outlook, etc.).	1	10.4
	23	19	To generate concept maps (e.g, Cmap), mind maps (e.g., xMind) or flowcharts (e.g., Visio).	1	6.3
	24	18	To create, modify and use conceptual diagrams, models or technical drawings.	3	6.9
	25	16	To sort large amounts of data (e.g., in a spreadsheet, online application, database, etc.).	2	7.4
	26	17	To produce graphs and data visualizations automatically from numerical data.	2	7.1
	27	15	To perform complex calculations (e.g., in a spreadsheet, statistics application, etc.)	Not used.	7.6
	28	21	To do some form of programming, coding, scripting or markup to automate processes.	Not used.	4.8

Table A2: GTCU Instrument (S, I and E) Items Ranked by Average Competency Score

Item #	Rank	Item Description	Order	Scenario	Avg. Score
11	**1**	To communicate with others using email.	S	1,2,3	16.8
12	**2**	To use online social-networking systems (e.g., Facebook, Twitter, LinkedIn, etc.).	S	1	16.5
8	**3**	To communicate with others using text messaging (SMS, Facebook Messenger, etc.).	S	2	16.4
17	**4**	To search and watch video online (e.g., YouTube).	I	1	15.4
9	**5**	To communicate with others using audio (e.g., phone, Skype, Viber, etc.).	S	Not used.	14.7
16	**6**	To search and access journal and/or news articles online.	I	1	12.9
10	**7**	To communicate with others using video (e.g., Skype, Google Hangouts, Adobe Connect, etc.).	S	Not used.	12.6
15	**8**	To access digital maps online (e.g., MapQuest, Google Maps) or use GPS to find my way or to get directions.	I	2	12.6
13	**9**	To use an online data/document sharing platform for collaboration (Google Apps, Dropbox, etc.).	S	2,3	11.9
19	**10**	To search, access and/or download music online.	I	Not used.	11.5
20	**11**	To search and download books (e.g., PDF, eBooks, audio) or purchase printed books online.	I	3	10.7
22	**12**	To use and share a calendar/personal agenda (e.g., Google Calendar, Outlook, etc.).	E	1	10.4
18	**13**	To search and access *images, photos or infographics* online. (Adjusted from *movies* for scenario).	I	3	9.7
14	**14**	To share my own ideas online with my network or the public (using blog, photo or video sites, etc.).	S	3	8
27	**15**	To perform complex calculations (e.g., in a spreadsheet, statistics application, etc.)	E	Not used.	7.6
25	**16**	To sort large amounts of data (e.g., in a spreadsheet, online application, database, etc.).	E	2	7.4
26	**17**	To produce graphs and data visualizations automatically from numerical data.	E	2	7.1
24	**18**	To create, modify and use conceptual diagrams, models or technical drawings.	E	3	6.9
23	**19**	To generate concept maps (e.g, Cmap), mind maps (e.g., xMind) or flowcharts (e.g., Visio).	E	1	6.3
21	**20**	To use an online application to collect and organize information automatically.	I	Not used.	5.6
28	**21**	To do some form of programming, coding, scripting or markup to automate processes.	E	Not used.	4.8

7.5 Appendix E: Performance Activity Descriptions

The following authentic (or, "real world) academic activities are set within the context of higher education. Each of the three activities is comprised of six tasks aligned with GTCU indicators, drawn from the Informational, Social and Epistemological dimensions.

Table A3: Scenario 1: Task Descriptions, Mapped Items, and Average Competency Scores

Scenario 1: "Presentation Planning" Reflecting on a research topic from your own educational experience, this six-step activity asks you to prepare and share materials for a fictitious presentation.		Average Competency Scores
Task 1	**Find a journal article** on your topic dated after 2012 from Google Scholar, or a database of your choice. Copy the citation for this article in APA format into a Google Doc, and write a short sentence describing the article's topic. [Item 16, I]	12.9
Task 2	**Find a YouTube video** related to the same topic/article. Record the shareable link and a brief rationale for your selection. [Item 17, I]	15.4
Task 3	**Schedule your presentation in Google Calendar**, providing a title and location (EILAB, UOIT). Select any weekday in February 2017, between 6pm and 9pm (EST). Invite todd.blayone@gmail.com to attend. [Item 22, E]	10.4
Task 4	Using Mindomo, a concept-mapping tool, **create a brief (3-4 node) outline of your presentation** (e.g., "Title," "Introduction," "Research Question…" etc.), and save in PDF format. [Item 23, E]	6.3
Task 5	Using your YouTube link, **share the video** as a post on the EILABB, UOIT Facebook profile page. [Item 12, S]	16.5
Task 6	**Email todd.blayone@gmail.com** with Subject Line "EILAB Activity 1." Provide links to (or attach) the information you collected during this activity. [Item 11, S]	16.8
[Aligned Survey Items: 16, 17, 22, 23, 12, 11; GTCU Orders: I, I, E, E, S, S]		**78.3**
Account Credentials **Google** (Gmail and Google Apps): eilab2.uoit@gmail.com (Password: $plotinus03) **Facebook**: eilab2.uoit@gmail.com (Password: $plotinus03) **Mindomo**: eilab.uoit@gmail.com (Password: $plotinus03) **Apple ID**: eilab2.uoit@gmail.com: (Password: $Plotinus03)		Average Reported Difficulty: 1.7/3 (Rank: 3)

Table A4: Scenario 2: Task Descriptions, Mapped Items, and Average Competency Scores

Scenario 2: "Democracy Data Analysis" The ***World Values Survey*** (WVS) is a global network of social scientists studying changing values and their impact on social and political life. In preparation for a symposium on education and democracy, this six-step activity asks you to select and manipulate data, and share this data with a collaborator via text messaging and email.		Average Competency Scores
Task 1	Before preparing your research data, which you will present at the (fictitious) *Education and Democracy Conference* in downtown Oshawa, **generate driving directions** from Pearson International Airport, Toronto to the Holiday Inn Express (Simcoe Street, Oshawa), and **save a copy or a link so they can be shared** in Task 5. [Item 15, I]	12.6
Task 2	**Prepare your research data**. Go to www.worldvaluessurvey.org. You will select and extract data on the "Importance of Democracy" (**variable V140**) for six countries: Columbia, Germany, United States, Sweden, Poland and Ukraine. To do this, perform an **Online Analysis** from the 2010-2014 wave. (Hint: **Online Analysis** is found under Data & Documentation in the left menu. Or, go directly to: http://www.worldvaluessurvey.org/WVSOnline.jsp). [Item 25, E]	7.4
Task 3	**Download the selected data from the web site, and prepare your Excel spreadsheet file for editing in *Google Sheets*.** With the resulting data table displayed online, download it as an Excel file, and open it in *Google Sheets*. You will need to convert the file to *Google Sheets* format (Hint: Share & export function) for editing, and save (or share) it to your *Google Drive*. [Item 13, S]	11.9
Task 4	**Create a new graph.** Delete the current graph. You will create a new bar graph displaying the total percentage of respondents (Y axis) from each country (X axis) who "highly value" democracy. You will define "highly value" as all response values from "8" to "Absolutely important" (inclusive) in the survey. When you have completed the graph, save it as a PDF or JPEG. [Item 26, E]	7.1
Task 5	**Text message your collaborator** (EILAB UOIT) using Facebook Messenger, and share your World Value Survey data and the saved driving directions. (Note: You are EILABB UOIT.) [Item 8, S]	16.4
Task 6	Finally, **email todd.blayone@gmail.com** with Subject Line "EILAB Activity 2." Please provide links to (or attach) the information/materials you generated/collected for this activity. [Item 11, S]	16.8
[Aligned Survey Items: 15, 25, 13, 26, 8, 11; GTCU Orders: I, E, S, E, S, S]		**72.2**
Account Credentials **Google** (Google Apps): eilab2.uoit@gmail.com (Password: $plotinus03) **Facebook**: eilab2.uoit@gmail.com (Password: $plotinus03) **Apple ID**: eilab2.uoit@gmail.com: (Password: $Plotinus03)		Average Reported Difficulty: 2.5/3 (Rank 1)

Table A5: Scenario 3: Task Descriptions, Mapped Items, and Average Competency Scores

Scenario 3: "Model Drawing" The *Community of Inquiry* (CoI) framework is a model of collaborative learning. The *Fully Online Learning Community* (FOLC) is a model derived from the CoI. One difference between these models is that CoI consists of three dimensions (Social, Cognitive and Teaching Presence), but FOLC consists of two dimensions (Social and Cognitive Presence) situated within a fully "digital space." This six-step activity involves the development and sharing of conceptual materials for a FOLC project.		Average Competency Scores
Task 1	**Prepare to collaborate**. Make a new folder in *Google Drive* called "Activity 3 – *your first name*" and share this folder with Todd (todd.blayone@gmail.com), ensuring that he has **VIEW permissions only** for this folder. [Item 13, S]	11.9
Task 2	**Find visual information**. Find a digital image of the *Community of Inquiry* conceptual diagram, and save it to the *Google Drive* folder (created in Task 1) as a design reference. [Item 18, I]	9.7
Task 3	**Create a similar visual model.** Using a drawing or presentation application of your choice (you may use an app on the device, or download one), and the CoI model as a general reference, create a new conceptual diagram for the FOLC model, showing two dimensions set within a "digital space" (as described in the activity description). Save this in the same *Google Drive* folder. [Item 24, E]	6.9
Task 4	**Gather information**. As a related research task, find the full bibliographic reference, in APA style, for D. Randy Garrisons's recent book entitled *Thinking Collaboratively*. Save the reference for sharing. [Item 20, I]	10.7
Task 5	**Publish information on social media**. Publish the FOLC diagram you created to your *Padlet*, a collaboration and information sharing platform. [Item 14, S]	8
Task 6	**Communicate**. Finally, email todd.blayone@gmail.com with Subject Line "EILAB Activity 3." Please provide a link to the *Padlet* containing the diagram, and the full bibliographical reference collected in Task 4. [Item 11, S]	16.8
[Aligned Survey Items: 13, 18, 24, 20, 14, 11; GTCU Orders: S, I, E, I, S, S]		**64**
Account Credentials **Google** (Google Apps): eilab2.uoit@gmail.com (Password: $plotinus03) **Padlet**: eilab2.uoit@gmail.com (Password: $plotinus03) **Microsoft**: eilab2.uoit@gmail.com (Password: $plotinus03) **Apple ID**: eilab2.uoit@gmail.com: (Password: $Plotinus03)		Average Reported Difficulty: 2.2/3 (Rank 2)

7.6 Appendix F: Video Analysis Coding Scheme (*The Observer XT*)

Table A6: Video Analysis Coding Scheme

Tasks (Durational Coding)	Review (Start / Stop) Perform Task 1 (Start / Stop) Perform Task 2 (Start / Stop) Perform Task 3 (Start / Stop) Perform Task 4 (Start / Stop) Perform Task 5 (Start / Stop) Perform Task 6 (Start / Stop)
Problem Types (Durational Coding)	Problem (See Description) (Start / Stop) Navigation (Start / Stop) Touch Input (Start / Stop) Task Comprehension (Start / Stop) Strategy (Start / Stop) Affordance Alignment (Start / Stop) Procedural (Start / Stop)
Technical Failures (Point Event Coding)	Device Technical Issue Software Application Issue
Competence Demonstrations (Point Event Coding)	Skillfulness Adaptiveness
Other Event Markers	Affordance selection Sign of Fatigue (e.g., yawn) Exploration Search for Information Signs of Impatience/Frustration (e.g., facial expression, voiced) Technical Problem-solving

7.7 Appendix G: Activity Performance Rubric

Table A7: Performance Assessment Rubric

Task Scoring	3 (High Quality)	2 (Medium Quality)	1 (Low Quality)
Processes / Procedures	Task completed confidently, in a strategic/logical manner with a minimum of identified problems, and avoidance of frustration, using well-selected software applications.	Task addressed with some tentativeness and problems, and/or with poorly selected tool(s)/application(s). Some expressions of frustration may be present and timeline is marked with some problems.	Task fully or mostly incomplete, and/or addressed in a very confused manner. Timeline marked with several problems during task. Task may also have been abandoned or not attempted.
Outcome(s) / Artefact(s)	Artefacts address the task goal directly, are accurate, and of good academic quality (appropriate to the individual's level of study).	Artefacts partially address the task goal, and/or are partly accurate, and/or are of medium academic quality (appropriate to the individual's level of study).	Artefacts are not present or are mostly incomplete, and/or do not address the task goal, and/or are of poor academic quality (appropriate to the individual's level of study).

7.8 Appendix H: Post Activity Interview

1. What phrase best describes the level of difficulty of today's activity: 1) relatively easy, 2) reasonably challenging, or 3) frustratingly difficult?
2. Reflecting on this activity, when did you feel most comfortable and confident?
3. When did you feel least comfortable and confident?
4. Based on your experience completing the survey and the performance activity, how would you characterize your readiness for fully online learning using a mobile device?
5. Do you have any other feedback on this experience?

7.9 Appendix I: Field Notes and Extracted Participant Interview Data

Perceived difficulty, reported during the post-activity interview, is measured on a three point scale (1 = "Relatively easy"; 2 = "Reasonably challenging"; 3 = "Frustratingly difficult.") General readiness for fully online learning with a tablet, and the most and least comfortable scenario tasks, were also reported in the post-activity interview as a response to prepared questions (Appendix H). The field notes presented here were made during live observation and the interview.

Table A8: Participant Field Notes and Extracted Interview Data

Participant	**Scenario #**	**Perceived Difficulty**	**General readiness for fully online learning with a tablet?**	**Summarized Field Notes (Observations and Interviews)**
P1	1	2	**Yes**. Suggested including video casting as a task.	Displayed very high confidence with device. Took a significant amount of time to complete Task 1. "Found it difficult to adapt to Google Docs on a tablet." Reported being least comfortable during the first task, but felt comfortable after. Expressed a strong interest in technology.
P2	2	3	**No.** "I don't know how to use a lot of apps."	Appeared to lack confidence, and it was not until 18:57 that the participant used Google to help find information to solve the WVS problem. Generally, pursued a rather confused approach to the activity. Reported being most comfortable tasks were sending email, using Facebook and Google Maps—activities that were familiar. "I thought the activity was great because it was so hard."
P3	1	2	**No**. "Tablets are too difficult to use" in educational contexts.	Medium level of confidence. Hesitant with many operations but displays a very calm approach to identifying and solving problems. Reported most comfortable using Google Docs. Least comfortable managing references/citations. "I've always been horrible at that." Sometimes appears to lose a sense of place on the device.
P4	2	3	**No**. "Need to take a workshop on the use of technology in learning."	Very tentative on the device and appears new to almost all task-related procedures. "I've never used an iPad before." "Technology is not enhancing my learning. It's hindering my learning." Reported being most comfortable "just seeing a familiar web page." Least comfortable "when I couldn't find out how to do something."
P5	2	2	**Yes**. "I'm pretty comfortable, but I'm concerned about using a tablet to its full potential."	Very confident user. Very calm response to a technical failure. Reported being most comfortable using email.
P6	1	1	**Yes**. "But typing notes in class would be challenging, and copy and paste would	Very comfortable with the technology (e.g., touch typing in the tablet) and pursued an incredible structured approach to scenario completion. "I like the way that the activity was broken down into single steps." "It's challenging looking for

			be frustrating. Much prefer a laptop."	journal articles, but I felt comfortable when I read that I could select a topic that interested me." I've never done much work on a tablet. I use it to watch Netflix." "If I had to use a tablet seriously, I would get a keyboard." Reported being least comfortable looking for journal articles.
P7	3	2	**Yes**.	Very confident user able to solve problems. Very deep understanding of iOS. Although extremely capable, it appeared that this participant preferred to finish quickly rather than spend time completing a task at a high quality. Reported being most comfortable using email. Least comfortable drawing a conceptual model.
P8	1	2	**Yes.**	Very high confidence and comfort with the device. "I still feel more comfortable reading and annotating printed." Regardless, this participant displays deep operational understanding of the iPad. Reported being least comfortable using Google Calendar.
P9	3	2.5	**Yes.**	Highly skilled, exploratory user who focuses on the quality of task completion. "This was definitely a fun experience. Really fun!" Reported being most comfortable selecting a drawing application. Least comfortable trying to find a good drawing application.
P10	2	2	**Yes**. Generally speaking.	Very tentative user. Lots of time spent exploring the environment. Reported being most comfortable using Excel. Least comfortable using Google Maps. "Never used the iPad before."
P11	3	2	**Maybe**. Mixed feelings.	Participant was slightly hesitant with the device. Moreover, she appeared to experience task comprehension problems, and a display an occasionally hesitant and somewhat meandering approach towards successful task completion. "Uncomfortable with Google Drive" on the tablet. "I really wanted a mouse and a keyboard." "I'm not a big fan of using a web cam." Reported being most comfortable when gathering information. Least comfortable with managing files on the tablet.
P12	1	1	**Yes**.	Very high confidence. "Mobile devices are powerful, but it takes longer to do things than on the laptop." Owns and iPad, and the comfort with which the participant "is one" with the touch interface is obvious. Reported being least comfortable when addressing task involving building a concept map, because "I did not know what a concept map is."
P13	1	2	**Yes**. But would prefer not to use a tablet.	Showed moderate comfort with the device. Expressed and demonstrated persistence when solving problems. When asked if the task or using the device was most challenging, responded "The device." Reported being most comfortable using email. Least comfortable finding a research article.

P14	2	2	**Yes**. I'm comfortable.	Participant appeared extremely tired, and at times, appeared to almost fall asleep. Counted five significant yawns spaced out throughout the activity. In one instance it looked like she was having a problem staying awake. This visible fatigue may explain the confused task-completion strategies. Tasks were routinely abandoned and then resumed. In one case, the participant behaved very agitated. Clicking her nails repeatedly on the device. Reported being most comfortable using Google Drive. Least comfortable drawing and using Padlet.
P15	3	2.5	**Yes**. I will learn by doing.	Appeared somewhat uncomfortable with tablet. Became increasingly frustrated when PowerPoint continually crashed while trying to draw a conceptual model. Also appeared mildly frustrated when she could not find a reference on Google Scholar, but interestingly, she did not proceed beyond the first page of results, and we later found it on the second page. Reported being most comfortable while using email. Least comfortable while searching for a bibliographic reference.

7.10 Appendix J: Self-Report and Performance Comparative Data Set 1

The following data set is grouped by scenario (Scenario 1: P1, 8, 6, 12, 3 and 13; Scenario 2: P5, 2, 10 and 4; Scenario 3: P14, 7, 15, 9 and 11), with participants in each scenario sorted by Total Performance Score (Column 4). The heading labels are as follows: **P#**: Participant Number; **DV**: Device Used; **DR**: Difficulty Reported; **SRS**: Scenario Reported Score; **SPS**: Scenario Performance Score; **TM**: Total Minutes (on scenario); **CM**: (Scenario) Completed?; I#: (aligned GTCU) Item Number (as referenced in Appendix D); **F1**, **F2**, **F3**: (GTCU) Frequency (of activity for device # (where computer/laptop is 1, smartphone is 2 and tablet is 3); **C1**, **C2**, **C3**: (GTCU) Confidence (of activity for device # (where computer/laptop is 1, smartphone is 2 and tablet is 3); **TRS**: Task Reported Score; **TPS**: Task Performance Score; **PS**: Process Score; **OS**: Outcomes Score.

Table A9: Comparative Analyses Data Matrix 1

P#	DV	DR	SRS	SPS	TM	CM	I#	F1	C1	F2	C2	F3	C3	TRS	TPS	PS	OS	I#	F1	C1	F2	C2	F3	C3	TRS	TPS	PS	OS	I#	F1	C1	F2	C2	F3	C3	TRS	TPS	PS	OS
P1	iPad	2	168	36	32	Y	**16**	5	5	5	5	5	5	30	6	3	3	**17**	5	5	5	5	5	5	30	6	3	3	**22**	5	5	5	5	5	5	30	6	3	3
P8	iPad	2	135	36	39	Y	**16**	3	4	4	4	2	4	21	6	3	3	**17**	3	5	4	5	4	5	26	6	3	3	**22**	2	5	5	5	2	5	24	6	3	3
P6	iPad	1	119	36	29	Y	**16**	3	4	3	1	2	1	14	6	3	3	**17**	3	5	5	5	4	5	27	6	3	3	**22**	1	4	1	4	1	1	12	6	3	3
P12	iPad	1	113	34	23	Y	**16**	3	5	1	4	2	5	20	6	3	3	**17**	4	5	3	3	3	3	21	6	3	3	**22**	2	3	5	4	1	1	16	5	3	2
P3	Sam	2	92	30	49	Y	**16**	3	3	2	2	1	2	13	4	2	2	**17**	5	5	3	5	2	5	25	5	2	3	**22**	2	3	1	3	1	3	13	5	2	3
P13	Sam	2	87	30	40	Y	**16**	5	5	2	4	2	4	22	4	1	3	**17**	3	4	1	1	2	4	15	5	2	3	**22**	1	2	1	1	1	1	7	5	2	3
P5	iPad	2	99	33	29	Y	**15**	3	5	3	5	1	1	18	6	3	3	**25**	2	3	1	2	1	1	10	5	2	3	**13**	5	5	4	5	1	1	21	6	3	3
P2	iPad	3	92	16	50	N	**15**	2	4	4	4	1	4	19	4	2	2	**25**	1	1	1	1	1	1	6	2	1	1	**13**	3	3	1	2	1	2	12	2	1	1
P10	iPad	2	92	27	50	Y	**15**	3	3	3	3	1	1	14	4	1	3	**25**	5	5	3	3	1	1	18	5	2	3	**13**	5	4	1	1	1	1	13	6	3	3
P4	iPad	3	62	13	50	N	**15**	4	4	1	1	1	1	12	3	2	1	**25**	2	2	1	1	1	1	8	2	1	1	**13**	4	3	1	1	1	1	11	2	1	1
P14	Sam	2	137	27	50	Y	**13**	5	5	5	5	2	5	27	5	2	3	**18**	5	5	4	5	4	5	28	5	2	3	**24**	1	2	1	2	1	2	9	4	2	2
P7	iPad	2	120	30	22	Y	**13**	5	4	1	4	3	4	21	5	2	3	**18**	4	4	5	4	4	4	25	6	3	3	**24**	1	1	1	1	1	1	6	3	2	1
P15	Sam	2.5	112	28	42	Y	**13**	5	4	1	1	1	1	13	5	2	3	**18**	4	4	2	4	3	4	21	5	2	3	**24**	2	2	1	1	1	2	9	5	2	3
P9	iPad	2.5	110	33	57	Y	**13**	3	3	5	3	2	3	19	6	3	3	**18**	2	5	5	5	2	5	24	6	3	3	**24**	2	3	2	3	1	3	14	5	2	3
P11	iPad	2	101	24	41	Y	**13**	4	3	2	2	3	3	17	4	2	2	**18**	2	5	2	5	2	5	21	4	2	2	**24**	2	3	1	1	1	1	9	2	1	1

P#	DV	DR	SRS	SPS	TM	CM	I#	F1	C1	F2	C2	F3	C3	TRS	TPS	PS	OS	I#	F1	C1	F2	C2	F3	C3	TRS	TPS	PS	OS	I#	F1	C1	F2	C2	F3	C3	TRS	TPS	PS	OS
P1	iPad	2	168	36	32	Y	**23**	3	5	1	1	3	5	18	6	3	3	**12**	5	5	5	5	5	5	30	6	3	3	**11**	5	5	5	5	5	5	30	6	3	3
P8	iPad	2	135	36	39	Y	**23**	2	4	1	3	1	4	15	6	3	3	**12**	3	5	3	5	2	5	23	6	3	3	**11**	4	5	5	5	2	5	26	6	3	3
P6	iPad	1	119	36	29	Y	**23**	2	3	1	1	1	1	9	6	3	3	**12**	5	5	5	5	4	5	29	6	3	3	**11**	5	5	5	5	3	5	28	6	3	3
P12	iPad	1	113	34	23	Y	**23**	1	1	1	1	1	1	6	6	3	3	**12**	5	3	5	3	4	3	23	6	3	3	**11**	5	5	4	5	4	4	27	5	3	2
P3	Sam	2	92	30	49	Y	**23**	1	1	1	1	1	1	6	6	3	3	**12**	4	3	4	3	1	1	16	6	3	3	**11**	4	5	1	4	1	4	19	4	1	3
P13	Sam	2	87	30	40	Y	**23**	2	4	1	1	1	1	10	5	2	3	**12**	2	2	1	1	1	1	8	5	2	3	**11**	5	4	5	4	3	4	25	6	3	3
P5	iPad	2	99	33	29	Y	**26**	2	3	1	1	1	1	9	4	2	2	**8**	3	4	5	5	1	1	19	6	3	3	**11**	5	5	5	5	1	1	22	6	3	3
P2	iPad	3	92	16	50	N	**26**	1	1	1	1	1	1	6	2	1	1	**8**	5	4	5	4	5	4	27	3	2	1	**11**	5	4	5	4	1	3	22	3	2	1
P10	iPad	2	92	27	50	Y	**26**	4	4	1	1	1	1	12	4	2	2	**8**	5	4	4	3	1	1	18	4	2	2	**11**	5	4	3	3	1	1	17	6	3	3
P4	iPad	3	62	13	50	N	**26**	1	1	1	1	1	1	6	2	1	1	**8**	2	3	2	3	1	1	12	2	1	1	**11**	5	4	1	1	1	1	13	2	1	1
P14	Sam	2	137	27	50	Y	**20**	2	5	2	5	1	5	20	4	2	2	**14**	5	5	5	5	2	5	27	4	2	2	**11**	5	5	5	5	1	5	26	5	3	2
P7	iPad	2	120	30	22	Y	**20**	4	4	1	4	3	4	20	5	3	2	**14**	3	4	4	4	3	4	22	6	3	3	**11**	5	4	5	4	4	4	26	5	3	2
P15	Sam	2.5	112	28	42	Y	**20**	3	4	1	1	2	4	15	3	2	1	**14**	4	4	4	4	4	4	24	5	2	3	**11**	5	5	5	5	5	5	30	5	3	2
P9	iPad	2.5	110	33	57	Y	**20**	2	3	2	4	2	3	16	6	3	3	**14**	1	3	1	3	1	3	12	5	3	2	**11**	3	5	5	5	2	5	25	5	3	2
P11	iPad	2	101	24	41	Y	**20**	1	2	2	4	1	2	12	5	2	3	**14**	1	4	1	4	1	4	15	5	3	2	**11**	5	5	5	4	4	4	27	4	2	2

7.11 Appendix K: Self-Report and Performance Comparative Data Set 2

The following presents a data set sorted by reported competencies on scenario-aligned items (RT), and total; performance score (PT). Total reported competency scores (including frequency and confidence for each of the computer, smartphone and tablet items) for each GTCU activity item is included. Bolded items are those aligned with a participant's randomly-assigned performance scenario.

Table A10: Comparative Analyses Data Matrix 2

P#	A#	G	AGE	ED	8T	9T	10T	11T	12T	13T	14T	15T	16T	17T	18T	19T	20T	21T	22T	23T	24T	25T	26T	27T	28T	FRT	RT	ART	PT	TM
P1	1	M	40	Education	30	28	30	**30**	**30**	30	30	24	**30**	**30**	30	30	30	30	**30**	**18**	16	30	30	30	6	572	**168**	**34**	**36**	**32**
P14	3	F	22	Business	27	27	26	**26**	27	**27**	**27**	24	24	26	**28**	20	**20**	12	26	9	**9**	13	13	9	9	429	**137**	**27**	**27**	**50**
P8	1	F	34	Education	25	25	22	**26**	**23**	23	24	23	**21**	**26**	27	27	24	15	**24**	**15**	10	15	14	13	6	428	**135**	**27**	**36**	**39**
P7	3	F	23	Education	26	22	24	**26**	26	**21**	**22**	21	24	24	**25**	24	**20**	6	19	6	**6**	6	6	6	6	366	**120**	**24**	**30**	**22**
P6	1	F	23	Education	28	23	8	**28**	**29**	14	29	22	**14**	**27**	27	25	17	6	**12**	**9**	8	9	7	7	7	356	**119**	**24**	**36**	**29**
P12	1	F	24	Education	28	16	16	**27**	**23**	13	14	23	**20**	**21**	21	11	17	6	**16**	**6**	6	9	6	6	6	311	**113**	**23**	**34**	**23**
P15	3	F	51	Economics	27	23	14	**30**	26	**13**	**24**	13	25	21	**21**	14	**15**	6	13	6	**9**	10	9	8	6	333	**112**	**22**	**28**	**42**
P9	3	M	22	Education	25	25	25	**25**	22	**19**	**12**	24	24	27	**24**	24	**16**	13	21	9	**14**	16	10	11	6	392	**110**	**22**	**33**	**57**
P11	3	F	30	Education	26	19	14	**27**	24	**17**	**15**	24	23	27	**21**	19	**12**	6	7	9	**9**	9	7	6	6	327	**101**	**20**	**24**	**41**
P5	2	F	22	Science	**19**	17	12	**22**	22	**21**	19	**18**	15	20	19	20	16	6	18	12	12	**10**	**9**	14	15	336	**99**	**20**	**33**	**29**
P3	1	M	26	Education	25	18	18	**19**	**16**	12	13	15	**13**	**25**	25	17	11	6	**13**	**6**	8	9	6	6	6	287	**92**	**18**	**30**	**49**
P10	2	F	22	Science	**18**	15	6	**17**	13	**13**	14	**14**	12	14	14	11	12	13	10	9	11	**18**	**12**	11	9	266	**92**	**18**	**27**	**50**
P2	2	F	24	Education	**27**	22	14	**22**	26	**12**	9	**19**	18	27	6	11	12	6	6	6	6	**6**	**6**	6	6	273	**92**	**18**	**16**	**50**
P13	1	F	46	Education	23	15	11	**25**	**8**	17	11	15	**22**	**15**	17	13	14	6	**7**	**10**	6	9	9	9	16	278	**87**	**17**	**30**	**40**
P4	2	M	41	Education	**12**	10	6	13	6	**11**	6	**12**	12	13	13	11	13	6	6	6	6	**8**	**6**	6	6	188	**62**	**12**	**13**	**50**

7.12 Appendix L: UOIT REB Approval Notice

REB Change Request Approved 13-082 / 12871

On Sep 22, 2016, at 2:33 PM, researchethics@uoit.ca wrote:

Date:	*September 22, 2016*
To:	*Roland van Oostveen*
From:	*Shirley Van Nuland, Chair, Research Ethics Board*
Title:	*(13-082) Assessing Digital Competence: Testing an Indirect Self-Report Instrument within the Technology Competency and Use (TCU) Framework*
Decision:	*CHANGE REQUEST APPROVED (submitted on August 24th, 2016 only)*
Current Expiry:	***February 01, 2017***

Notwithstanding this approval, you are required to obtain/submit, to UOIT's Research Ethics Board, any relevant approvals/permissions required, prior to commencement of this project.

The University of Ontario, Institute of Technology Research Ethics Board (REB) has reviewed and approved the change request related to the research proposal cited above. This request has been reviewed to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2 (2014)) and the UOIT Research Ethics Policy and Procedures. The REB requires that you adhere to the protocol as last reviewed and approved by the REB.

Continuing Review Requirements (forms can be found on the UOIT website):

- **Renewal Request Form**: All approved projects are subject to an annual renewal process. Projects must be renewed or closed by the expiry date indicated above ("Current Expiry"). Projects not renewed within 30 days of the expiry date will be automatically suspended by the REB; projects not renewed within 60 days of the expiry date will be automatically closed by the REB. Once your file has been formally closed, a new submission will be required to open a new file.
- **Change Request Form**: Any changes or modifications (e.g. adding a Co-PI or a change in methodology) must be approved by the REB through the completion of a change request form before implemented.
- **Adverse or Unexpected Events Form**: Events must be reported to the REB within 72 hours after the event occurred with an indication of how these events affect (in the view of the Principal Investigator) the safety of the participants and the continuation of the protocol (i.e. un-anticipated or un-mitigated physical, social or psychological harm to a participant).
- **Research Project Completion Form**: This form must be completed when the research study is concluded.

Always quote your REB file number (13-082/12871) on future correspondence. We wish you success with your study.

Dr. Shirley Van Nuland
REB Chair
shirley.vannuland@uoit.ca

Janice Moseley
Research Ethics Coordinator
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