THE USE OF MOBILE DEVICES FOR FORMAL LEARNING IN HIGHER EDUCATION: INVESTIGATING STUDENT BEHAVIORS AND EXPECTATIONS

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Robert Edward Elliott Jr.

THE USE OF MOBILE DEVICES FOR FORMAL LEARNING IN HIGHER EDUCATION: INVESTIGATING STUDENT BEHAVIORS AND EXPECTATIONS

The use of mobile devices has transformed the way we live, work, and study. Nearly every student in higher education owns a smart phone and the majority of those that do report that they use those devices, at least in part, to conduct academic work. Institutes of higher education (IHEs) have widely adopted technologies to connect instructors and students, and most instructors incorporate digital materials into their curriculum. However, the selection of these learning technologies is often the domain of the institution or the instructor. Students are expected to provide the personal technology required to utilize these systems, which may include their mobile device. The purpose of this study is to discover what types of academic work students would like to perform on their mobile devices, what barriers to doing so they have encountered, how their learning behavior differs based on the device in use, and students' preferred instructional design practices for designing learning activities on mobile devices.

A mixed-methods approach was used to answer these questions. Surveys and focus groups asked students about the personal technology that they own, the learning activities they perform, and how different devices are used to complete those activities. The log data of the Canvas learning management system was also analyzed to detail student behavior in the context of the device being used to interact with the system.

The results show that students do use their mobile devices for significant amounts of academic work and consider them to be an important educational tool, but they are generally selective about the types of activities in which they will engage on a mobile device. Students tend to use their mobile devices for activities that are most convenient to them but identified several factors that prevented

them from using those devices to engage in more detailed work. This study will inform instructors and instructional designers who produce academic content for students and assist IHEs in their decision-making process when adopting course materials and technologies.

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List of Abbreviations

COI(s): Community of Inquiry (Garrison et al., 1999)

HU: Hudson University, a pseudonym for the university that was the site of this study

IHE(s): Institute of Higher Education

LMS: Learning Management System, most relevantly the Canvas LMS in use at Hudson University

UDL: Universal Design for Learning Framework (CAST, 2018; Tobin, 2018)

Terminology and Definitions

E-Learning (eLearning; elearning)
The transduction of instructional materials (texts, resources, and lectures) that have historically been provided in physical formats into their digital counterparts. (Bezemer & Kress, 2008)

Individualized Activity
A learning activity that is designed for the learner to participate individually at their own pace and at the time and place of their choosing, as referenced in Activity Theory (Kaptelinin & Nardi, 2006).

LMS (Learning Management System)
A software product that coordinates the typical learning process, including the delivery of learning resources, affordance of communication between instructors and learners, submission of learning assessments, and delivery of feedback from instructor to learner. (Curinga & Saravanos, 2016)

Mobile Device
For the purposes of this study, a mobile device is defined as "… one that uses a mobile operating system (such as iOS, Android, and iPadOS) rather than devices that run a full version of an operating system (including laptops and hybrid tablet/laptops such as the Microsoft Surface)" (see Definitions of Mobile Device and Mobile Learning on page 10).

Mobile Learning (mLearning; m-learning)
For the purposes of this study, mobile learning is defined as "mLearning is the intersection of mobile computing and elearning: accessible resources wherever you are, strong search capabilities, rich interaction, powerful support for effective learning, and performance-based assessment. elearning independent of location in time or space" (Quinn, 2000, p. 1). See Definitions of Mobile Device and Mobile Learning on page 10 for more information.

Socialized Activity
A learning activity that is dependent on the interation of multiple learners in order to successfully meet learning outcomes, as reference in Activity Theory (Kaptelinin & Nardi, 2006)

Transactional Distance
Transactional distance describes the interplay between instructor and learner during a learning process. ***Low transactional distance*** refers to a learning activity that is expected to take place between instructor and learner in concert, with significant interaction and interplay. ***High transactional distance*** learning activities, on the other hand, are designed so that the instructor and learner can be distant in both space and time and work toward the learning objective can continue independently without interaction between instructor and learner (Moore, 2018).

Chapter 1: Introduction

Context and Background

In 1996 George Kuh argued that a student's academic experience in higher education does not depend solely on what is done in the classroom but is instead a complex interaction between a student's entire experience (Kuh, 1996). He describes the combination of in-class and out-of-class events as a seamless learning environment – one in which learning can come from anywhere and students have myriad opportunities to make meaning by connecting different experiences. His argument notes that higher education professionals – including instructors and instructional designers – should build opportunities for students to wisely use their time outside of the classroom to further support their academic work. Responding to the students' actual lived experience, he suggests, can improve their academic performance as it becomes interwoven into the multiple social contexts through which students move. The ACPA notes that it is imperative to "…create conditions that motivate and inspire students to devote time and energy to educationally-purposeful activities, both in and outside the classroom" (ACPA, 1996, p. 1).

As higher education – indeed, society as a whole – evolves, the technology used for everyday purposes continues to evolve as well. Higher education has become inextricably intertwined with technology (Becker et al., 2017; Gierdowski, 2019) and students are increasingly bringing more personal technology with them (Gierdowski et al., 2020). In a study by Gierdowski et al. (2020), 96% of students rated access to Wi-Fi as their most important technological feature for studying. This phenomenon is both intrinsic, as students see the value of using technology to support their studies (Gierdowski, 2019), as well as extrinsic, as most institutions have adopted learning management systems (LMS) for communication and organization of instructional materials (Pomerantz et al., 2018). In another study by Pomerantz et al. (2018), 88% of faculty were found to use at least some features of the LMS, which indicates they expect students to engage with some form of technology. However, fewer than half of

students report that faculty encourage them to use their personal technology to make deeper meaning of their studies (Gierdowski et al., 2020) and half of students report that faculty ban personal technology in the classroom even though many students prefer digital versions of textbooks and other course resources (Gierdowski, 2019).

The use of mobile devices for personal learning has been steadily increasing over time and it has been demonstrated that students are comfortable using their devices for schoolwork (Seilhamer et al., 2018). Smart phones are the most common mobile device in use, as 94% of global internet users owned a smart phone in 2019 (Mander et al., 2020). Mobile phone ownership among college students in the United States is nearly absolute (Galanek et al., 2018). Most students are comfortable with their devices and want to use them to perform tasks related to their courses (Al-Emran et al., 2016; Magda et al., 2020; Rataj & Wojcik, 2020; Seilhamer et al., 2018). The increased student preference for using mobile devices follows other innovations in higher education content delivery, such as open educational resources and electronic course materials and texts. Students increasingly prefer to use these technologies, partially due to their higher convenience and lower cost (Delimont et al., 2016; Jensen, 2018).

As the reliance on technological innovations for higher education increases and the delineation of activities performed on specific devices becomes more blurred, we appear to be reaching a tipping point where Kuh's (1996) seamless learning environment becomes possible. Students are already crossing the boundaries between in-class and out-of-class learning by virtue of the digital contexts in which they perform academic work (Kukulska-Hulme & Traxler, 2019). Research is needed that will reveal how students use their devices, including the specific activities they perform and the environmental factors that lead them to choose one device or the other (B. Chen & deNoyelles, 2013).

Problem Statement

There appears to be a disconnect between the implementation of technology and digital resources by instructors and the technology that students use for their academic work (Gierdowski, 2019). The distribution of course materials via a learning management system (LMS) is done so in a top-down fashion where the instructor has control over the format and delivery method (Mpungose & Khoza, 2020; Schoonenboom, 2014). Supplemental documents, course videos, discussions, and a variety of digital learning tools (e.g., interactive exercises) are used in concert with readings to produce a holistic package of content that ushers the student toward successful completion of learning objectives (Henderson et al., 2017). This transduction of information from mere texts to other forms of media is pervasive and, often, commonplace (Bezemer & Kress, 2008). This style of technology-enhanced learning is supposed to provide more control to the learners by affording them more flexibility in the time and space where they engage with the content (Laurillard, 2002; Taylor et al., 2006). But if the technology through which the material is delivered does not match the technology through which the students are able to or choose to engage with it, then the benefits of the technology-enhanced learning are diminished or lost (Taylor et al., 2006).

The instructional design process puts instructors and designers in the driver's seat and educational content made available to students is only made available on specific platforms over which the student has no agency (Schoonenboom, 2014). This is the case at Hudson University (a pseudonym), a large, public, multi-campus institution in the midwestern United States, which is the location for this study. Hudson University's e-text initiative (Abaci et al., 2020), for example, only allows access to student texts on laptop or desktop computers. In addition, video embedded in the Canvas LMS courses via Kaltura ("Video Cloud Platform for Education," n.d.), .Hudson's selected educational video hosting provider, are not visible when Canvas course content is viewed through the LMS's standalone mobile applications (*IPads Blocking 3rd Party Cookies Breaks Kaltura Embeds. Any Workaround?*, 2019; *Kaltura -*

Known Issue - Students on Mobile Devices Receive "No Source Video Was Found" Error When Viewing Kaltura Media (UW-Madison), n.d.; *Kaltura LTI Videos Not Playing in the Canvas App*, 2016) Thus, students are being provided with course content that should support their ability to meet learning objectives but are hamstrung into reviewing that content on the limited platforms on which it functions, which may not match their needs or preferences.

It would be impractical and cost-prohibitive to expect all digital content offered in a higher education setting to be designed with a mobile-first approach. Instead, instructional design efforts should focus on the delivery of academic content that is most valuable to students in a mobile format (Benson & Samarawickrema, 2009; Park, 2011). The alignment of instructional design to student needs and preferences is an important area of study that has been overlooked thus far in the research. Studies related to student preferences and outcomes often include short questions about the technology (e.g., devices) students have available, but do not specifically ask students to delineate which types of activities are (or can be) performed on a given device. For example, students increasingly read electronic textbooks (Delimont et al., 2016; Ward & Edmondson, 2019) and view video content related to their courses (Bishop & Verleger, 2013) but we do not know on which devices the students are able to use to review said content. We do not know if the format of the provided content aligns with the devices students have available (or would prefer to use) in their studies. Without this information we cannot streamline the instructional design process to ensure the most relevant and useful content is provided to students in a mobile context.

Description of the Study

This study investigates the use of mobile devices by students in higher education to support their formal learning processes. It intends to discover the specific academic activities students would prefer to perform using a mobile device – and the incompatibilities or barriers students have encountered when trying to do so.

Research Purpose and Questions

This study is centered on the following research questions:

1. What types of academic work do students want to perform on their mobile devices at a large public university?
2. What barriers do students encounter when using their mobile devices for formal learning at a large public university?
3. How does a student's learning behavior differ based on the device in use at a large public university?
4. What do students believe are best practices for the design of learning activities on a mobile device?

Significance of the Study

As trends in casual media consumption via mobile device continue to increase, it is expected that those habits will transfer to formal media consumption related to education and employment. This shift has been quantified in the trend of using personal devices for educational purposes (Lieberman, 2019). Students have begun to demand that the materials provided by the institution conform to their consumption preferences (Gierdowski, 2019). Further, the COVID-19 pandemic forced the industry to rapidly transition to entirely remote learning. This provided a unique, albeit emergency, opportunity for Institutions of Higher Education (IHEs) to consider the disconnect between the technology they provide and the technology students had at their disposal (Grajek, 2020; IUPUI, 2020; Snapp-Childs et al., 2020). As IHEs continue their work to improve student success and engagement and increase the variety of modalities through which they offer courses, it would be in their best interest to minimize any friction between the delivery of academic content they provide and the acceptance of those materials by their students.

This study sheds light on students' experiences, perceptions, and preferences for accessing digital course materials which will inform instructors and instructional designers who produce academic content for students and assist IHEs in their decision-making process when adopting course materials and technologies. Once we have a better understanding of how students are engaging with course materials, we can improve our instructional design practices (Baldwin & Ching, 2020) and make informed demands of our technology suppliers for products and services that meet student needs (Dickson-Deane, 2020).

Definitions of Mobile Device and Mobile Learning

The speed of innovation related to mobile technology has never allowed for formal definitions to be adopted, to the point where researchers have "…retreated from an authoritative definition of mobile learning" (Traxler, 2010, p. 130). Yet, a shared understanding of the vernacular is necessary to ensure clarity in the descriptions, arguments, and proposals within this document.

The term "mobile device" is widely used and can be applied to any portable technology from a laptop computer to a personal wearable device. The vague terminology is interpreted differently by researchers, resulting in studies that focus only on smart phones (Gikas & Grant, 2013), those that include phones and tablets (S. Cross et al., 2019; Foti & Mendez, 2014), and yet more that include laptops as a third device type (Ding et al., 2020). Occasionally, authors of a study will omit their definition of mobile device entirely (Saroia & Gao, 2019). Rieger and Majchrzak (2017) attempted to mediate this issue with a proposed taxonomy to categorize various portable computing systems, but no common definition has been made. The disparity in interpretation can make it challenging to compare different studies.

For the purposes of this study, I define a mobile device as one that uses a mobile operating system (such as iOS, Android, and iPadOS) rather than devices that run a full version of an operating system (including laptops and hybrid tablet/laptops such as the Microsoft Surface).

The notion of “mobile learning” (sometimes written as “mLearning” or “m-learning”) is equally broad. I rely on the definition provided by Quinn (2000): “mLearning is the intersection of mobile computing and elearning: accessible resources wherever you are, strong search capabilities, rich interaction, powerful support for effective learning, and performance-based assessment. elearning independent of location in time or space” (p. 1). I prefer this interpretation because it is not dependent on a single technology or device family and includes the notion that the learner can engage in learning activities anytime and anywhere.

Chapter 2: Literature Review

Educational researchers have been studying the impact of mobile technology in higher education in earnest since the advent of the 21st century (Attewell & Savill-Smith, 2005; Pea & Maldonado, 2006). Early research examined the impact of handheld technologies in many disciplines, including natural biology (Y.-S. Chen et al., 2002), clinical nursing (Kenny et al., 2009), and exercise science (Bruce-Low et al., 2013). These studies showed that the devices, then primarily supplied by the educators or institutions, did help achieve the learning objectives set forth for the students. However, technical limitations and unfamiliarity with the devices presented challenges. Further, as noted by Sharples (2015), few of these studies addressed how to maintain a "seamless continuity of learning" as students change their physical and social context (p. 41).

In a very short time, some of the initial technology barriers mentioned in earlier studies have greatly diminished as society has incorporated mobile devices into everyday use. Smart phones are the most common mobile device in use, as 94% of global internet users owned a smart phone in 2019 (Mander et al., 2020). Mobile phone ownership among college students in the United States is nearly absolute (Galanek et al., 2018). Most students are comfortable with their devices and want to use them to perform tasks related to their courses (Magda et al., 2020; Rataj & Wojcik, 2020; Seilhamer et al., 2018).

Researchers debate whether designers should specifically incorporate mobile devices into instruction. Dyson, et al, (2009) stated plainly that "The priority must be to design an educational strategy for active, experiential m-learning. This might include, for example, mobile supported fieldwork, hands on learning, role plays and games" (p. 251). Others instead suggest that "…an institution's mobile strategy should center on the user experience, which starts with recognizing those mobile resources that have the most impact and value" (Seilhamer et al., 2018). These statements summarize two schools of thought related to instructional activities on mobile devices: should instruction be designed

specifically *for* mobile devices, or should instruction be designed so that it can be used by *any* device, including mobile?

Instructional Design Inclusive of Mobile Devices

Kukulska-Hulme and Traxler (2019, p. 1) state frankly that "(e)ducation is no longer designed for a group of learners situated in a defined context; rather teachers face the challenge of designing for individuals who engage in their own learning, through their own devices, from their own settings, and on their own terms." No specific technology has been the cause of this transition. Indeed, Neil Selwyn (2016) notes that "(t)he past 100 years show that education has been largely un-transformed and un-disrupted by successive waves of technological innovation." The modes of communication between instructors and students will continue to ebb and flow; we may be focused on mobile devices in the present but there are more technologies on the horizon (Frick, 2020). Instead, as noted by Ting (2012), we should reflect and review the theories, pedagogies, and instructional design frameworks that allow us to craft content and learning activities in a way that fits into our new educational paradigm – one that affords flexibility for instructors and learners in terms of environment, geography, time, and learning objectives. Ting states frankly that "(t)he use of mobile devices in learning should go beyond the technical functionalities, and stress the contextual use of mobile devices" (p. 124).

As the nature of technology used by students and instructors is in flux, researchers should consider the core components of successful learning interventions. Kukulska-Hulme and Traxler (2019) suggest that we should move beyond designing *for* mobile devices and instead design educational experiences irrespective of the tools used. Thus, instructors and instructional designers should first consider general design principles when developing content and learning activities rather than focus on the needs of specific devices and should prioritize the activities that are most likely to be performed on a mobile device (Liu et al., 2010). The goal should be to focus on the nature of the content and the outcomes of the learning activities rather than the specific environments within which the learning is

conducted. More flexible academic materials would afford students more agency in deciding the device they choose to use and the time and place when the learning occurs.

Formal vs. Informal Learning

Learning is no longer confined to the classroom (Halliday-Wynes et al., 2009), nor is it constrained to the activities prescribed by the instructor. Livingstone (2004) notes that academic activities fall on a spectrum with a range from "dominant teacher control" to "dominant learner control" (p. 203) yet notes that within this continuum there are four general categories of activities based on the initiation and structure of each. These categories were adapted from Livingstone's work by Taylor, et al. (2006) and can be reviewed in Table 1.

Table 1
Categories of formal and informal learning

	External Structure	**Internal Structure**
External Initiation	Formal learning	Resource-based learning
Internal Initiation	Voluntary learning	Informal learning

Academic activities that are initiated and structured by an instructor are classified as formal learning. At the other end of the spectrum are informal academic activities that are initiated and structured wholly by the learner. Voluntary learning allows an individual learner to embark on a structured activity of their own volition, and resource-based learning is when an external individual asks the learner to craft the structure of the academic activity on their own (Taylor et al., 2006).

It is important to note that these classifications are purely subjective and are used as a convenience while studying education and learning. Dib (1988) argues that formal learning is, in fact, becoming less formal as the communication between instructor and learner becomes less contiguous and suggests that activities such as reading assignments or reviewing assigned materials on one's own constitutes a more informal academic activity than continuous interaction with the instructor. Colley, et al. (2003) note that it is pure habit to treat informal and formal learning differently and argue that there

is no way to create firm definitions for different learning classifications. Curinga and Saravanos (2016) note that “formal/informal learning is not (and never has been) a binary distinction” (p. 24). Sharples (2015) echoes the arguments of Kuh (1996) in his argument that instructional design should support a seamless flow of academic activities regardless of initiation, structure, or physical context. Students often incorporate multiple activities while working toward a single objective, and they tend to enhance their formal learning experiences with connectivist, informal, learning methods. (Gikas & Grant, 2013; Transue, 2013).

Because academic activities fall anywhere along this spectrum, pat definitions of learning formality seem inadequate. However, it is possible to provide a reasonable distinction between formal and informal learning for the purposes of this study. Cross describes formal learning as a bus where a driver (instructor) chooses the route and decides where to stop while the passengers (learners) are just along for the ride (J. Cross, 2007). Livingstone (2006) defines informal learning as “…any activity involving the pursuit of understanding, knowledge, or skill that occurs without the presence of externally imposed curricular criteria” (p. 206). With these two extremes in mind, this study will focus on how learners execute academic activities that are scaffolded and prescribed by an instructor or instructional designer for the purposes of meeting a specific learning objective.

Technology-Enabled Academic Activities in a Community of Inquiry

A community of inquiry (COI) is defined as a coalition of instructors and learners with three essential elements: (1) teaching presence, (2) cognitive presence, and (3) social presence (Garrison et al., 1999). Teaching presence is broken into two primary responsibilities: (1) the instructional design of the experience and (2) the facilitation of the cognitive and social aspects. Cognitive presence details the ability of learners to make meaning from the educational experience. Social presence consists of the ability for members of the community of inquiry to exchange ideas and ask questions. The social aspects

of the community likely support the cognitive presence by allowing members to collaborate to make meaning.

Technology-enabled academic activities fall into one of three categories that neatly align with the elements of a COI: (1) **instructional tasks** that are prescribed by the instructor, which includes content to be consumed by the student (teaching presence), (2) **learning activities** in which the student participates or demonstrates their grasp of learning outcomes (cognitive presence) (Benson & Samarawickrema, 2009), and (3) **communication and interaction** that affords conversations both formal and informal between the instructors and students (social presence). All three components are critical to formal learning and should be examined with regard to the user experience and the activity's usability on a mobile device. A potential fourth classification of a technology-enabled academic activity that is not yet widely discussed is that of **recording academic activity**, such as the use of a smart phone to take photos or video of classroom or personal artifacts or the digital recording of a classroom activity or lecture.

Instructional tasks include primarily static information provided to the learner to support the learning outcomes of a course (Tobin, 2018). This information might be delivered by textbooks, lectures and/or lecture materials by the instructor, instructional videos, electronic texts, and digital supplements (e.g., PowerPoint slides). Whatever the resource may be, these materials are intended to be consumed by the student with little to no interaction and, in most cases, outside of a scheduled class meeting. Thus, the review of these resources can be undertaken at the time and place of the student's choosing. Although the student has agency over when and where these activities are performed, the fact that they are prescribed by an instructor and contain structure to support future activities means that these instructional tasks can be classified as formal academic activities for the purposes of this study.

Learning activities – described as "learning tasks" by Benson and Samarawickrema (2009) – on the other hand, require more interactivity and engagement on the part of the student (Tobin, 2018).

Examples of learning activities include both formative and summative assessments (e.g., quizzes, exams, essays, papers, or presentations) and interactive learning exercises (e.g., lecture response and polling, synthesis of academic content, research and data collection, or simulations). Learning activities are scheduled by the instructor and may take place either during or outside of a synchronous class meeting. The time and place for learning activities that are scheduled outside of a class meeting are, again, primarily at the student's discretion. Learning activities are the primary means of assessment that allows the instructor to understand the progress the learner has made toward accomplishing a learning objective. Therefore, learning activities would also qualify as formal learning for our purposes.

Communication within a COI is perhaps the most flexible aspect of its design, as it can contain messages for both formal and informal learning. Formal learning might be represented by social learning opportunities (such as discussions, debates, and reflective conversations), in which case the social presence begins to blend with the cognitive presence through a structured activity. However, informal learning may also occur as members of the community interact. Informal learning may include messages from the instructor to all students (which may facilitate the teaching presence), between an instructor and one (or a select few) students, or from a student to the instructor. The medium for these communiques is primarily prescribed by the instructor, although student preferences may result in communication in multiple forms. And learners within communities of inquiry frequently communicate with their peers in support of meeting their learning objectives (Gikas & Grant, 2013).

Faculty Implementation of Instructional Technology

Institutions of Higher Education (IHEs) in the United States have broadly adopted Learning Management System (LMS) technology and approximately 88% of faculty report even minimal use of an LMS (Pomerantz et al., 2018). A literature review of faculty experience with the technology used to support blended learning – the most common of which is a learning management system – shows that instructors predominantly use the technology for administrative purposes to improve their efficiency

(Torrisi-Steele & Drew, 2013). This is supported by studies that show faculty predominantly use the LMS for the top-down dissemination of academic materials to students (Mpungose & Khoza, 2020). The implementation of which specific academic activities are enabled in the learning management system is left to the instructor's discretion, and those that are included tend to be driven by the importance of the task and the ease of use of the corresponding LMS tool (Schoonenboom, 2014).

Schoonenboom (2014) has delineated 18 specific academic activities – primarily instructional tasks and learning activities – that an instructor might implement within an LMS. The academic activities that are deemed important by instructors and have the lowest barriers to implementation in a learning management system include the distribution of lecture notes and additional reference documents, answering student questions, displaying instructional videos, and providing feedback from instructor to student. Tasks that are rated as important to instructors but are not as easy to implement in an LMS include scheduling and holding individual meetings with students, student discussions, collaborative writing assignments, exams, and blog or reflective posts. This demonstrates that LMSs tend to be used more frequently for instructional tasks of a formal learning nature – the top-down delivery of materials from instructor to student – than learning activities in which the student engages.

Theories and Frameworks Related to Instructional Technology and Mobile Learning

Transactional Distance Theory

Transactional Distance theory (TD) describes three separate components that compose distance learning: an instructor, a student, and a means of communication (Moore, 2018). Moore notes that "the 'transaction' in distance education is the interplay of the behaviors of teachers and students in environments in which they are in separate places and have to communicate through a technology" (p. 33). Thus, distance learning cannot exist in the absence of any of the required components – there would be no transactional portion of the learning process.

Three general categories of variables in transactions between instructor and learner exist: dialogue, structure, and learner autonomy (Sivula, 2019). Dialogue refers to actual interactions between instructor and learner. Structure represents the course design and its associated components. Learner autonomy recognizes that learners have varying levels of self-sufficiency and some learners desire more independence than others. The theory hypothesizes that courses with higher transactional distance (i.e., more structure and less dialogue and interaction) could be more appropriate for learners who are more autonomous.

Benson and Samarawickrema (2009) developed an intricate look at instructional design that maps specific learning content to the learners' transactional distance and provides suggestions about building instruction from a context-aware perspective. However, concerns have been noted that transactional distance theory does not sufficiently account for social interactions between students themselves (Kang & Gyorke, 2008). Therefore, transactional distance may help shape the instructional design from the perspective of delivery of instructional tasks but may not provide a comprehensive view of all academic work inclusive of learning activities and interactions.

Although the transactional distance theory was originally proposed specifically in the context of distance education, Moore himself has noted that many features of traditional distance education have been integrated into standard face-to-face courses (Moore, 2018). The advent of digital learning tools and learning management systems has transmuted elements of physical classrooms into their digital equivalents, which has left a loosely defined gray area often referred to as "blended learning." However, no set definition of blended learning exists – certainly not one that clearly delineates the amount of technology use that tips a face-to-face classroom into the blended learning category (Pomerantz et al., 2018). Instructional tasks, such as distributing assignments and handouts, are frequently performed via LMSs even in face-to-face courses (Torrisi-Steele & Drew, 2013). Notably, Heinze and Procter (2004) demonstrate that reliance on technology increases as the traditional face-to-face classroom assumes

elements that were once reserved for distance learning courses. The authors of an EDUCAUSE LMS research report argue that "…it may be time to stop considering trivial uses of online tools (such as using an LMS to post a course syllabus) as worthy of qualifying a course as 'blended'" (Pomerantz et al., 2018, p. 4).

The adoption of LMS technology into courses of all modalities affords an opportunity to examine at least two of the variables of the transactional distance theory in nearly any course context. Dialogue can be in the form of messages initiated by the instructor (such as announcements, emails, or discussion posts) and communications initiated by students (including emails to the instructor or fellow classmates or discussion board messages if made available by the instructor). The structural component of the transactional distance theory is then supported by the technology tools used to deliver instructional tasks and, less frequently, accommodate learning activities.

The third variable of transactional distance, learner autonomy, may not be directly impacted by the technology in use in the course, but recent trends show that students see value in the ability to control how they engage with their coursework for varied reasons including personal preference, physical environment, and time constraints. Students have reported that their self-efficacy is influenced by their school environment and the level of autonomy it provides (Schunk & Pajares, 2002). Further, there is a correlation between one's self-determination – their personal preferences – and their intrinsic motivation to participate in an activity (Ryan & Deci, 2000). Taylor et al. (2006) concluded in an early examination of mobile learning practices that individuals know what kinds of resources they need and will seek those out when and where they need them. With these factors in mind, there is value in ensuring that the academic environment matches the expectations of students – which is, increasingly, related to the devices that they use while engaging in academic work. One study notes that 74% of online college students want to use a mobile device to access their course activities no matter where they are (Magda et al., 2020). In another survey, students noted that the two most beneficial features of

learning technologies are mobility and flexibility, and that 82% of students noted that digital learning technology allowed them to spend more time studying because of its easier access (Research, 2017). Students have also been found to align their academic activities with their environment, thus having a choice of activities allows them to be more efficient with their time as their location and context changes (S. Cross et al., 2019). The implementation of academic activities in such a way that allows the student to assume control over the time and device used can thus increase a student's level of autonomy.

Activity Theory and The Task Model for Mobile Learning

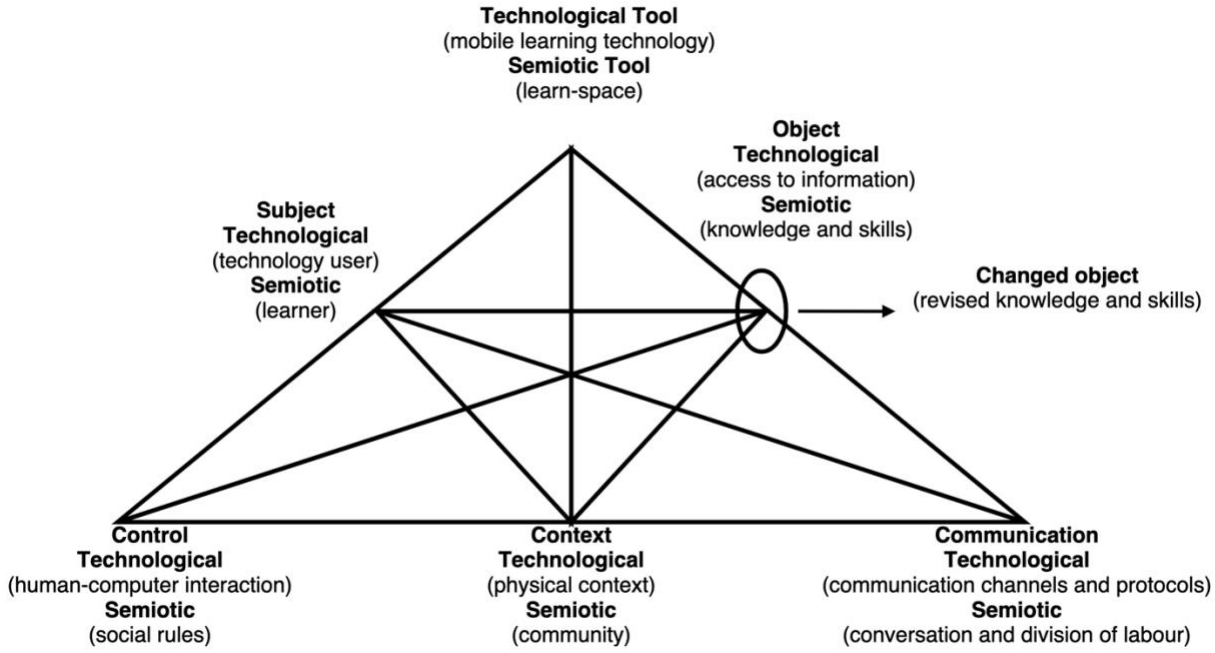
Activity theory examines the interaction (the "activity") between a subject and an object and observes the development of both subject and object as a result of the activity (Kaptelinin & Nardi, 2006). Activity theory has been used frequently in interaction design and human-computer interaction to explain the net effects of the interaction between individuals (subjects) and the systems (objects) that they are using (Nielsen, 1986). From an instructional design perspective, activity theory treats the individual activities (and the discrete actions contained within), as conveyed by a tool, to be the primary driver of change in the student and the learning objective. Thus, the interactions – and the tools that accumulate and transmit information between them – must be given primacy in instructional design.

Activity theory has frequently been used to examine the impact of learning mediated by technology, including studies by Gay and Hembrooke (2004) and Jonassen and Rohrer-Murphy (1999). Chung, et al. (2019) performed a meta-analysis of mobile learning studies that were framed through the activity theory lens, which demonstrated that mobile devices were primarily used for learning content delivery (an individualized activity, as defined in activity theory)(2019).

Researchers have noted, however, that an expansion of activity theory is necessary so that the activities can be studied in situ with the acknowledgement that external factors can affect the outcome of any given activity. Taylor, et al., (2006) built on an expanded model of activity theory by Engeström

(1987) to develop the Task Model for Mobile Learning (see Figure 1). Taylor argues that theories specific to mobile learning are necessary because "(m)ost theories of pedagogy…fail to capture the distinctiveness of mobile learning. This is because they are theories of teaching, predicated on the assumption that learning occurs in a classroom environment, mediated by a trained teacher" (2006, sec. A theory of use for mobile learning). This enhanced model adds in the factors of control, context, and communication to the previous elements of subject, object, and tool. The task model, then, allows researchers to examine and more accurately classify mobile learning implementations in both their activity as well as their structure.

Figure 1
The Task Model for Mobile Learning



The control aspect of the Task Model refers to the benefit afforded by technology that allows a learner to access materials at the time and place of their choosing, thus providing them the opportunity to work at their own pace and according to their own schedule. This benefit can be lost if the application or delivery mechanism is not usable on a mobile device or does not meet the user's needs (i.e., the font size is too small to be read on the screen and there is no way for the learner to increase it).

Control is also limited by social norms, such as when and where it is appropriate or allowed to use a mobile device. Context refers to the technology itself as well as the environment in which it is to be used (which can be influenced by the societal norms in the control aspect). The Task Model considers communication to be at the core of mobile activities by learners because communication is the original and primary use of mobile devices. Thus, it is a natural extension of the use of mobile devices to integrate them into one's learning activities.

Instructional Design Considerations for Academic Activities and Materials

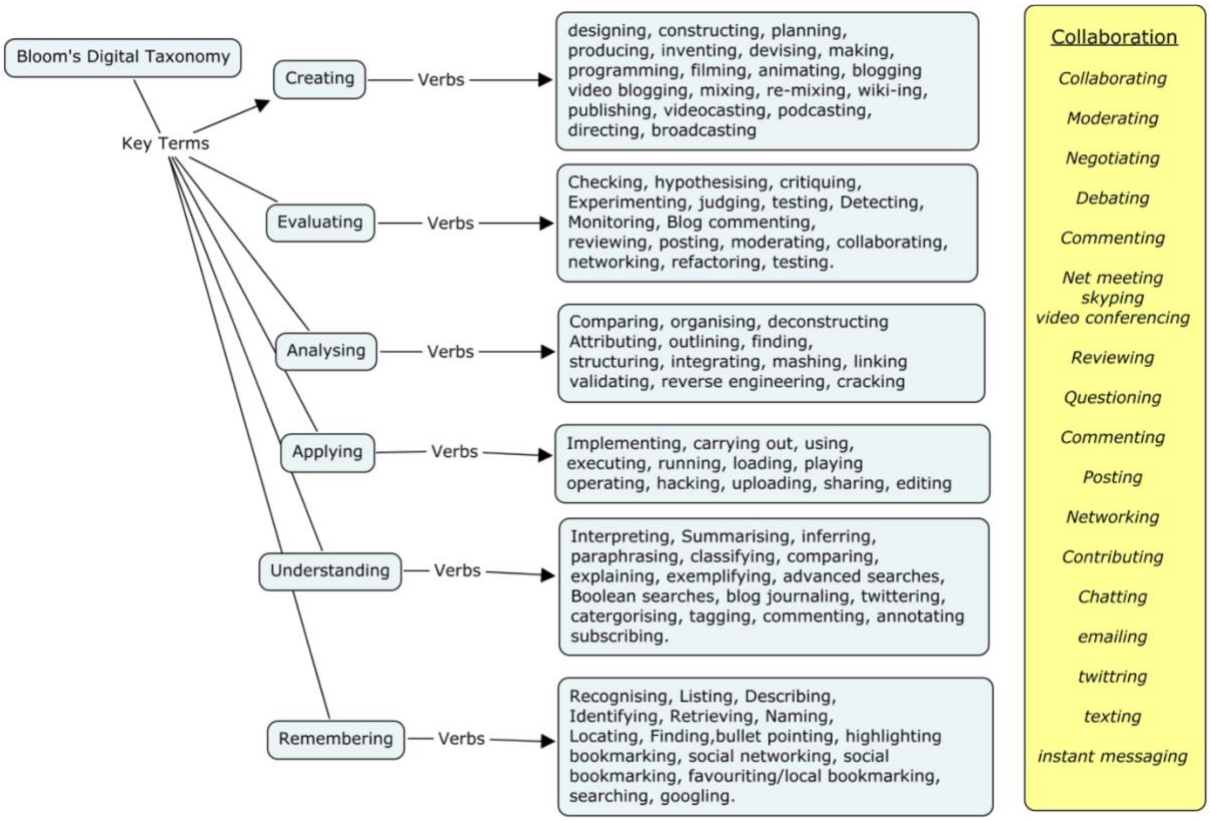
The rapid pace of smart phone adoption meant that students were naturally incorporating their devices into their learning activities before it was possible to develop and modify existing instructional design frameworks to include the mobile context (Kukulska-Hulme & Traxler, 2019). The phenomenon continues to outpace researchers' ability describe a fundamental model for mobile learning (Daughtery & Berge, 2017), which has presented a challenge to building and testing frameworks for comparison. Traxler (2010) notes that the literature lends one to see the wide variety of mobile learning implementations rather than provide narrow sets of guidelines. Still, guidance from the aforementioned theories has allowed researchers to use existing constructs to model recommendations that guide the development of academic materials that can be used on mobile devices.

Bloom's Taxonomy, Bloom's Revised Taxonomy, and the Digital Taxonomy

The original Bloom's Taxonomy of educational objectives (1956) was a mechanism to consolidate the language of educational assessment (Munzenmaier, 2013). It was not conceived as a set of guidelines so much as it was a classification system to allow common understanding when establishing, measuring, sharing, and comparing learning objectives. A major revision of the taxonomy was performed in 2001 that introduced a separation of the knowledge and cognitive dimensions for the purpose of clarification as well as to accommodate advances in learning theory and cognitive psychology (Anderson et al., 2001). Churches (2008) then built on the revised taxonomy to incorporate digital

technologies and cognitive objectives. A mind map of Bloom's Digital Taxonomy built by Churches can be found in Figure 2. The culmination of these works provides a common language and classification mechanism to use when describing the different academic activities that are commonly administered from instructor to learner.

Figure 2
Mind map of Bloom's digital taxonomy created by Andrew Churches (2008)



At the low end of the scale are objectives classified as "remembering" – opportunities for lower-order thinking tasks including recognizing, listing, and describing. Churches' digital taxonomy includes tasks that must be performed on a device, such as social bookmarking and using a search engine. The high end of the scale contains objectives related to "creating," which includes digital activities such as video editing and podcasting. These classification levels are useful for conversations related to specific instructional design activities, particularly when discussing activities that require the use of a

technological device. These can also be cross-referenced to the 18 specific instructional tasks delineated by Schoonenboom (2014) for further analysis and discussion.

Universal Design for Learning

Universal Design for Learning (UDL) reinforces the notion that learning is inherently a social activity (Meyer et al., 2014), and builds on the notions of Bandura's theory of self-efficacy (1977) in recognizing that all individuals have different learning preferences and may need varying levels of support to achieve successful learning outcomes (Boothe et al., 2018). The framework is intended to empower learners "…by giving them more control over their lives and choice in the things that they do or the way in which they do those things" (Salmen, 2011, p. 15).

UDL is a highly inclusive pedagogical framework that firmly places the needs of the learner first. UDL's learning guidelines (CAST, 2018) suggest three primary tenets that guide instructional designers to (1) provide multiple means of engagement, (2) provide multiple means of representation, and (3) provide multiple means of action and expression. Of those three, the second – multiple means of representation – is likely the most critical when considering the design of learning resources. Specifically, designers should "…offer ways of customizing the display of information, offer alternatives for auditory information, and offer alternatives for visual information" (CAST, 2018). Doing so, CAST asserts, "…highlights the importance of providing varied media to meet diverse learners' perceptual preferences and needs" (Meyer et al., 2014, p. 63).

The notion of perceptual preferences and needs is important when considering the design of learning activities in which students can engage regardless of device. Students have expressed a preference to use mobile devices for learning activities (Asiimwe & Grnlund, 2015) and many students – particularly those who are "…students of color, students with disabilities, first generation students, students who are independent…and students who come from disadvantaged socioeconomic backgrounds" (Galanek et al., 2018, p. 11) – have demonstrated a need to incorporate their mobile

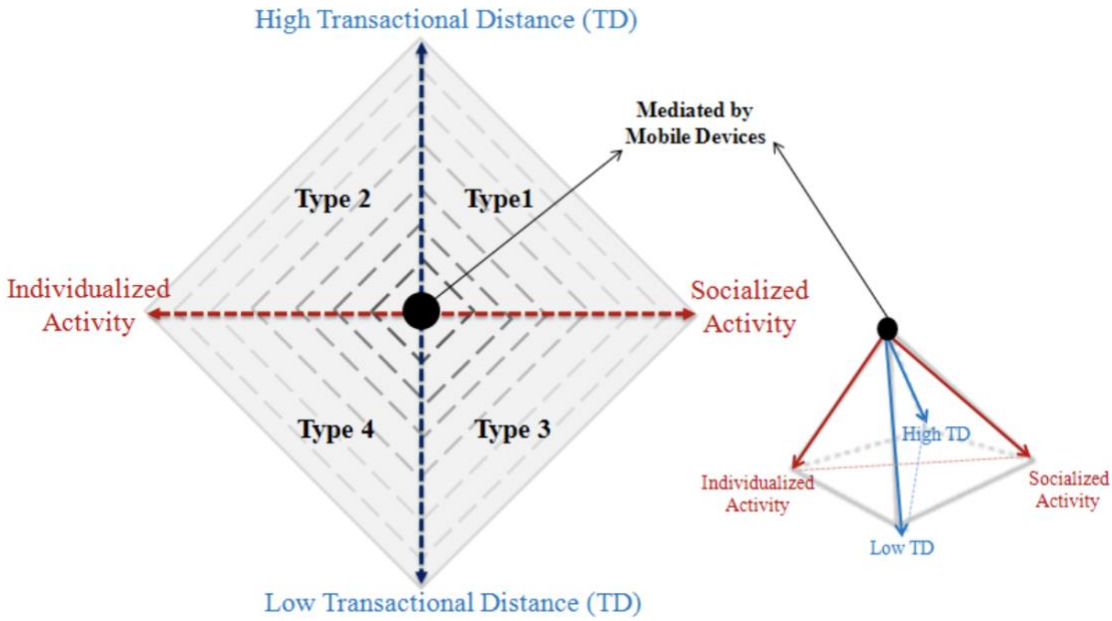
device into their studies. Thus, UDL proposes that the instructional design must afford equal access to learning resources and activities regardless of the technology available to the learner.

Implementation of UDL principles in higher education has been successfully demonstrated. In a study of a large lecture course, instructors found that the organization and distribution of course content and activities in alignment with the UDL framework were well-received by students and led to improved student outcomes (Dean et al., 2017). Although the aforementioned study did not focus on the devices used by students, the course content and activities were organized in PowerPoint files, an electronic textbook, and activities such as audience response and flashcards – all of which could be easily delivered to a mobile device.

Park's Pedagogical Framework for Mobile Learning

Park (2011) developed a classification scheme that incorporates both Activity Theory (Nardi, 1996) and Transactional Distance Theory (Moore, 2018) for the purposes of defining the tasks the students perform and the environment in which they execute those tasks. Doing so, Park believed, would allow instructional designers to make more nuanced decisions related to the development of learning activities that could include the use of a mobile device. Park proposes a framework that consists of four types of mobile learning (discussed below) and describes tasks appropriate to the transactional distance and expectations for social engagement.

Figure 3
Park's pedagogical framework for mobile learning (2011)



Park's pedagogical framework provides a means for instructional designers to begin to categorize learning resources and activities by those that are acceptable to the students and feasible to produce given timeline and budget constraints. Any activity mediated by a mobile device (as denoted in

Figure 3

Park's pedagogical framework for mobile learning (2011)) will pivot between two perpendicular axes: a horizontal range that encompasses the range of individualized to socialized activities, and a vertical axis that describes the amount of transactional distance the activity necessitates. This affords a general categorization of an activity in two distinct parameters which can help define the appropriateness of that activity for use on a mobile device. Activities that fall into the categories where students have expressed a stronger demand for mobile access (S. Cross et al., 2019) can then be prioritized.

Type 1: High Transactional Distance/Socialized Mobile Learning Activity

This type of activity requires instructors and designers to provide a scaffolded, collaborative experience in which multiple learners can engage either synchronously or asynchronously with little to no interaction with the instructor. Development concerns may include the need to structure and monitor social roles as well as the creation of content that is engaging enough to encourage students to participate throughout. Equity may also be a factor, as the design will need to accommodate the hardware and connectivity available to each student.

Type 2: High Transactional Distance/Individualized Mobile Learning Activity

More individualized activities are possible when the learning materials have been structured well and the learners can participate without frequent intervention from the instructor. This style of learning activity is most flexible with regards to the environment and context of the learner; thus, it is more suitable for students who are more independent or for activities that may take a varying length of time for individuals to complete. The delivery of traditional learning resources (reading materials and recorded videos) would fall neatly into this classification. Therefore, this categorization aligns neatly with the delivery of instructional tasks, as described in Technology-Enabled Academic Activities in a Community of Inquiry on page 15.

Type 3: Low Transactional Distance/Socialized Mobile Learning Activity

Activities in this category include less structure but more communication. Instructors may participate in this type of intervention but would primarily be available for facilitation and guidance. The learners themselves must interact to reflect, collaborate, or discover resources that are then shared in a common space. One might consider this the most similar to a standard small group activity within a physical classroom. The development of interventions of this type requires initial guidance and input from the instructor – as well as a clear set of deliverables and expected outcomes – but the majority of interactions will take place within the student's groups. This style of activity could include interactive discussions, collaborative annotation of readings and documents, or other loosely scaffolded activities. Specific software may be required for particular activities but is not generally a concern.

Type 4: Low Transactional Distance/Individualized Mobile Learning Activity

Summative assessments (e.g., papers, assignments, quizzes, presentations) form the basis for low transactional distance, individualized activities. Instructors are present for guidance and consultation but the activity itself prompts the learner to independently demonstrate their mastery and synthesis of the learning materials. Unless a specific technology is required, students should generally be able to perform these activities using the tools they have available. The low transactional distance indicates that learners will have less choice related to the time and place where the activity occurs. These activities correspond with the learning activities defined in Technology-Enabled Academic Activities in a Community of Inquiry on page 15.

Analysis of Existing Mobile Learning Implementations

An examination of the literature affords us the opportunity to analyze trends related to the implementation of mobile learning practices. I have selected two meta-analyses that can provide insight into common practices in mobile learning implementation and span a significant part of the last 20 years. The first analysis evaluates just over 100 projects leading up to the end of 2007, which will include some of the earliest studies of mobile technology as we understand it today (Frohberg et al., 2009). A

second review builds on the first and encompasses the years of 2010-2016, which includes the timeframe where rapid personal adoption of smart phone technology and, therefore, its ingrained use into both work and education, truly took hold (Chung et al., 2019). Both studies used the Task Model for Mobile Learning (Taylor et al., 2006) as their means of classifying the literature, which provides a consistent view of implementation over time.

The tools used to facilitate learning processes – which, arguably, might be the element of most interest to this study – were classified into five pedagogical roles based on a scale of increasing cognitive impact. Starting with the lowest cognitive function, the classifications are rote content delivery (i.e., instructional tasks), interaction for motivation and control (which was clarified to mean short quizzes and low-stakes assessments), guided reflection, reflective data collection, and content construction (i.e., learning activities). This scale is a slightly consolidated but consistent version of Bloom's revised taxonomy (Anderson et al., 2001). In both literature reviews, the tool classifications most commonly implemented were content delivery and interaction for motivation and control – the two classifications with the lowest cognitive impact. This indicates that the studies primarily used the mobile devices for one-way transmission of academic content from instructor to learner. There was a slight uptick of use of mobile devices for guided reflection in the later analysis (Chung et al., 2019) which may indicate instances where students used their devices to submit opinions or reflections in either text or audiovisual format, which mobile devices would have easily allowed.

An examination of the context of the mobile learning activities allowed the classification of each study into one of four context-related categories: independent (meaning the physical environment of the learner has no meaning), formalized (primarily used to refer to a classroom-based activity), physical (the learning activity takes place in a prescribed location – such as on a field trip), or socializing (which is dependent on other learners). The earlier analysis found studies that took place in all contexts, although there were far more that utilized the independent context than another other classification and very

few in the socialized context (Frohberg et al., 2009). The later analysis showed a transition in this measure and saw a large increase in the number of studies that were dependent on a learner's physical location than was previously noted (Chung et al., 2019). This change make sense when one considers the adoption of personal mobile technology in the last decade or so. More learning activities in specific physical environments could take place once mobile device ownership became more ubiquitous and institutions no longer had to distribute devices to everyone. Simultaneously, the drop in the number of studies examining mobile learning in the independent context may indicate implicit understanding that mobile devices were being used for some learning activities and further research into that area may have seemed redundant or less expository.

The control factor relates to the structural nature of the learning activity, and whose responsibility it is to set the parameters for the event. The studies were classified on a five-element scale ranging from full teacher control to full learner control. The earlier analysis showed that instructors were firmly in control and took full responsibility for the prescribed learning activities – almost twice as many studies were labeled "full" teacher control as the next classification of "mainly" teacher controlled (Frohberg et al., 2009). The later review demonstrated an easing of this phenomenon and classified the majority of mobile learning studies as "mainly" teacher controlled (Chung et al., 2019). The authors of the later study note that learners in this class of activity are given relatively rigid guidelines to follow, but it is possible that they are asked to locate some resources on their own (such as a Web search). Again, the normalization of mobile device usage appears to have influenced this trend, although it shows that teachers are still quite strict in the guidelines put forth for these learning activities.

The communication classification describes the amount of interaction that the learning activity requires in order to be successful. The five-element range of classifications spans from isolated learners through cooperation (where groups are required to communicate). Both the earlier and later analyses

show that instructional tasks are overwhelmingly geared for isolated learners or the next highest classification of loose couples, with little change in the trend over time. This is an interesting result, given the overwhelming amount of attention paid to the social capabilities of mobile devices (S. Cross et al., 2019; Gikas & Grant, 2013; Mpungose, 2020). However, it is also possible that the studies included in these analyses are focused on formal, rather than informal, learning events and the social interactions the devices enable are simply not captured in this research.

The factor related to the learner attempts to classify the level of expertise held by the target of the learning activity. Again, the studies were examined on a scale of five values ranging from novice to expert. The earlier analysis reported that 85% of the mobile learning activities were targeted to novice learners (Frohberg et al., 2009) but the most common classification in the later study was the second level "little previous knowledge" (Chung et al., 2019). Again, this shows a slight evolution in the design of mobile learning activities, which could be a result of the technology's increasing maturity coupled with the increasingly common use over time.

Finally, an analysis of the objective of each mobile learning activity was performed to see what type of cognitive abilities were invoked. The results of both the earlier and later analyses demonstrate that mobile learning activities were overwhelmingly built for lower order thinking tasks labeled "know" and the next lowest "comprehend." This demonstrates that instructors and instructional designers are using mobile learning activities primarily to provide foundational knowledge in the form of instructional materials between instructor and student. This finding aligns with the use of the tool classification, which showed that content delivery was the most common usage by far.

Based on the examination of mobile learning activities over time we can make some generalizations about their implementation. It is apparent that mobile devices are primarily used for lower-order tasks that require less cognitive ability, and that those activities are defined and controlled by the instructor. Most activities are built to take place independent of physical environment (although

the ubiquity of devices makes more location-specific activities possible) and by individual students. The activities appear to be targeted toward novices and focused on content delivery and low-stakes interactions. Thus, it can be surmised that mobile devices have been primarily seen as a tool to support the activities that can be found at the lower end of the revised Bloom's taxonomy (Anderson et al., 2001).

Chapter 3: Methods

Research Design

This is a mixed-methods study which collects quantitative data in the form of an anonymous survey offered via the Qualtrics survey platform and qualitative data from focus groups with students (Research Questions 1-4). Additional quantitative data comes from the analysis the automated usage logs of the Canvas Learning Management System (LMS) at Hudson University (HU).

The purpose of analyzing the automated log data from Canvas is to discover any distinct differences in user behavior based on the type of device used when interacting with the LMS (e.g., time on task, specific LMS tools used, etc.) This analysis provides information on *actual* user behavior and guided the development of the questions for both the survey as well as the focus group discussions.

Research Context

The study is conducted at Hudson University (a pseudonym), a major research university in the US Midwest with over 90,000 students. Enrolled students of any level (undergraduate and graduate) will be asked to participate. HU has seven physical campuses (including a core residential campus, a large urban semi-residential campus, and five regional campuses) and a slate of exclusively online programs. HU also has two satellite campuses, whose students have been grouped within other campuses where appropriate. All students in an online program are also assigned to one of the seven campuses.

Limiting the study to Hudson University students ensures that all participants will have generally worked with the same suite of technology in their education. However, the results of the study should be broadly generalizable to any institution of higher education (IHE) that uses a similar technology stack.

Sampling Plan

Eligible participants included anyone who was part of the entire student body enrolled at any Hudson University campus in the Fall 2021 semester. Approximately 30% of the students at every

campus were included in the initial sample. The anonymous survey asks students a set of demographic questions (including their major, age, and enrollment status) to ensure that the quantitative analysis is representative of the student body as a whole. Purposive sampling of the responses ensures that a variety of disciplines and campuses are represented.

Focus group participants were drawn from multiple disciplines and campuses and will also be asked to provide some non-personally identifiable demographic information to accurately group their responses.

Logistics

Recruiting for Survey and Focus Groups

Students at all seven physical campuses and the online-only programs were recruited for the study. 30% of the student body was identified in the initial sample, and invitations were made via emails delivered through the Qualtrics survey management system. Any student enrolled in any academic program at Hudson University who is over the age of 18 was eligible to participate.

Focus group participants were recruited in a similar fashion. At the conclusion of the survey, respondents were offered the opportunity to participate in a focus group. Focus groups were conducted via Zoom to allow for easy interaction between students in multiple geographic regions (and in compliance with COVID-19 travel and meeting restrictions).

Institutional Review Board (IRB) approval was obtained for data collection in the survey and focus groups.

Canvas LMS Data Analysis

Data from the automated Canvas logs was provided by Hudson University's eLearning Research and Practice Lab (*ELearning Research and Practice Lab*, 2021)

Data Security

The survey was distributed using the Qualtrics online survey software. There was no personally identifiable information recorded in the survey data but it will be housed within Qualtrics' secure website. This data is classified as Restricted by Hudson University's Management of Institutional Data policy, therefore downloaded data for data analysis will be stored in a secure folder via Hudson University's Microsoft Secure Storage.

Focus group sessions will be recorded via the Zoom recording capability and will be transcribed. Recordings will be used only for transcription purposes and will be destroyed once transcribed. Participants will be identified by pseudonyms through the coding and reporting processes. All documentation (transcripts, codebooks, etc.) will be stored in the same Microsoft Secure Storage.

All LMS data is deidentified from the start. The original data is stored in a secure, cloud-hosted database with extremely limited access. Aggregate data exported from the database will be stored in secure storage while analysis is conducted.

Data Analysis

Data Source 1 – Anonymous Student Survey

The student survey asked the students questions themed into the following categories:

- Broad demographics (i.e., gender, year in school, campus, major discipline)
- Technology ownership and comfort (i.e., devices owned, confidence in usage)
- General technology usage (i.e., tasks performed on desktop vs. mobile, preferences for media consumption and interpersonal communication)
- Academic technology usage (i.e., what types of academic work do they perform, what can they not perform, what would they *like* to perform)

Survey questions were drawn from multiple sources, including my own observations with students, and inspired by widely cited studies and reports (S. Cross et al., 2019; Galanek et al., 2018; Gierdowski et al., 2020; Gikas & Grant, 2013). The specific LMS-related activities that were noted in the

survey was initially modeled on the list developed by Schoonenboom (2014). The complete survey instruments that were used can be found in Appendix A – Survey Instrument for Anonymous Student Survey (Group 1) on page 113 and Appendix B – Survey Instrument for Anonymous Student Survey (Group 2) on page 125. Although most survey questions are generalized, more specific questions were developed based on the results of the analysis of the Canvas log data. For instance, students on mobile devices appeared to view Assignment information and Discussion activities more frequently than other activities so the survey inquired about those actions specifically.

The results of the survey were analyzed with both descriptive and inferential statistics (Leedy & Ormrod, 2016). Internal consistency of the survey was validated via Chronbach's Alpha to ensure relevant questions are included. Invalid or outlier questions were dismissed from the analysis.

Crosstabulations and multiple regression analyses (Flick, 2015) were performed to reveal relationships between demographic and usage/preference factors (i.e., do students from regional Hudson University campuses tend to use their devices differently than students at the core campuses? Is there a difference in technology confidence between students in different disciplines?)

Data Source 2 – Student Focus Groups

Students from all Hudson University campuses were invited to participate in focus groups where I asked more direct questions related specifically to the Canvas LMS and other software tools available to HU students and their use with mobile devices. The initial questions for the focus groups are found in Appendix C – Initial Questions for Student Focus Groups on page 113. I asked the students to provide specific examples of tools they felt would benefit them, barriers they have encountered in the use of mobile devices, and use cases related to how, when, and where they would like to have access to course materials. Students who were unable to join one of the scheduled focus groups were invited to submit comments via email. The email invitation that was sent is found in Appendix D – Email Request for Additional Information from Students Who Could Not Participate in Focus Groups on page 136.

Transcripts of the focus groups were coded in multiple ways. First, basic constant comparison analysis allowed for the dissection of the conversation into discrete units of data (Saldana, 2016). Those data were each coded, the codes were grouped, and themes were drawn from the codes. While reviewing the transcripts, I also performed a micro-interlocutor analysis (Onwuegbuzie et al., 2009), which encourages the reviewer to be aware not just of what is being said, but what is *not* being said as well. Information can also be drawn when certain focus group members are silent from the discussion of specific topics.

Data Source 3 – Canvas Usage Logs

Each interaction with the Canvas LMS results in a record of the activity. The data contained in these records includes the following items used to perform this study:

- Student ID
- Course
- Action *(Assignment, Discussion, Gradebook, etc.)*
- Date/Time
- Device used *(Mac computer, Windows computer, Android device, iOS device, etc.)*
- Interface used *(Canvas website, Canvas Student app)*

A sample of a complete log entry can be found in Appendix E – Sample Canvas Log Recordon page 138. Specific fields of interest from the log entries were transformed into relational database hosted on the Google Cloud Platform. I used Standard Query Language (SQL) to select actions made by students only (i.e., excluding instructors, teaching assistants, and staff) and group and order related events within the database. The database schema can be found in Appendix F – Database Schema of Transformed Canvas Log Data on page 140. Sample records from the database are location in Appendix G – Sample Record of Canvas Log Data Relational Database Table on page 141.

Canvas log events were grouped into sessions based on the user's ID, the Canvas course ID, and the time of the event. A session was defined as a student's ongoing interaction with the LMS within one specific course (i.e., if a student completed activities within one course and moved to another a new session was created). Any events which occurred in succession were considered part of a single session. A session was considered to be concluded if no additional actions had occurred within 25 minutes. Each action within a session was then numbered sequentially, which provided a record of the process the student undertook during their interaction with the LMS course.

Once this information was in hand, I used data analysis techniques and descriptive statistics (Leedy & Ormrod, 2016) to elucidate the following information to answer Research Question #3:

- How much activity takes place on desktop/laptop devices vs. mobile/tablet devices?
- Is there a difference in LMS tools used on desktop vs. mobile devices? Are specific tools used more frequently on mobile than on desktop?
- Is there a difference in the length of time students spend in Canvas based on the device used? For example, do students on average spend more time reading a Discussion board on the desktop than they do on a mobile device?
- Is there a difference in the usage pattern between students of different ages, campus types, enrollment status, or discipline?

Chapter 4: Results

This chapter presents the analysis of data collected in support of the following research questions:

1. What types of academic work do students want to perform on their mobile devices at a large public university?
2. What barriers do students encounter when using their mobile devices for formal learning at a large public university?
3. How does a student's learning behavior differ based on the device in use at a large public university?
4. What do students believe are best practices for the design of learning activities on a mobile device?

Data Collected

Anonymous Student Survey

All students over the age of 18 who were enrolled in the Fall 2021 semester at any Hudson University campus or online program was eligible to participate in the anonymous student survey. A sample of 26,966 eligible students was created. From this sample, 149 individuals were removed because of invalid email addresses. This sample represented approximately 30% of all eligible participants at HU. However, because the survey was extensive and the sample population was so large, it was decided to divide the survey into two parts and distribute each to half of the sample. Both surveys contained standard demographic questions and some common questions related to the students' preferences for using mobile devices for academic work. The first survey focused on the students' actual use of mobile devices for academic work and notetaking and was sent to 13,395 valid recipients. 1,065 completed responses were received (7.9% response rate). The second survey asked students to describe how they used their mobile devices in general and compare that use to the academic activities they

undertook. The second survey was sent to 13,418 valid recipients. From that sample, 1,081 completed responses were received (8.1% response rate).

Both surveys were opened on October 11, 2021 and remained open for 28 days until November 8, 2021. Survey invitations were delivered via Qualtrics' internal email distribution system. All participants received an initial invitation to participate followed by two reminder messages sent at weekly intervals.

Focus Groups and Emailed Student Responses

Three 90-minute focus groups with students from all campuses and programs of Hudson University were held in October and November 2021. Respondents to the survey were asked if they would like to participate in one of the focus groups or respond via email. A total of 20 students representing a range of campuses and programs participated in the focus groups, which were recorded and transcribed. The initial questions asked in each focus group can be found in Appendix C – Initial Questions for Student Focus Groups on page 113. Nine additional students who wished to participate but could not meet at any of the scheduled times submitted answers to questions via email. The invitation to participate by email can be found in Appendix D – Email Request for Additional Information from Students Who Could Not Participate in Focus Groups on page 136.

Automated Canvas Log Data

The automated log data for the Canvas LMS instance at Hudson University was obtained with IRB permission. All records for the Fall 2019 semester were downloaded and transformed into a relational database. The Fall 2019 semester was selected because it was the last complete semester before the disruptions introduced by the COVID-19 pandemic in Spring 2020. Therefore, this period provides a more robust snapshot of traditional student behavior absent the external influences of the pandemic. Note, however, that although some demographic subgroups were analyzed in aggregate, this

data does not include any connection to the individual users. Therefore, there can be no connection between the respondents to the survey and their behavior in Canvas.

Further data processing allowed for calculations of the device used, time on task, duration of the individual Canvas session, and the order of events as the student progressed through that session. A sample record from that data can be found in Appendix G – Sample Record of Canvas Log Data Relational Database Table on page 141. After processing the data, there were 152,127,914 individual interactions between students and the Canvas LMS.

Demographics and Technology Ownership

Survey respondents were asked to note which electronic devices they own or regularly use, which included both mobile devices as well as desktop computers. 2,061 survey respondents indicated that they owned at least one electronic device. The three most commonly owned electronic devices were a smart phone (98.3%), laptop (92.4%), and tablet (35.1%). Complete ownership results can be found in Table 2. Because e-readers and basic mobile phones offer extremely limited functionality with regards to academic work, their ownership was removed from the remainder of the analysis. A plurality of students (48.8%) owns just two electronic devices and 37.7% of students own three devices.

Table 2
Electronic device ownership (n = 2061)

Device	# of Students Who Own	Percentage of Respondents
Smart Phone	2,026	98.3%
Laptop	1,905	92.4%
Tablet	724	35.1%
Desktop Computer	521	25.3%
E-Reader	125	6.1%
Chromebook	115	5.6%

"Basic" Mobile Phone	10	0.5%

Survey respondents were categorized by several demographic categories, including undergraduate/graduate status, gender, race/ethnicity, age, campus of enrollment, enrollment status, major in school, school of enrollment, state residence, campus residence, international student status, first generation student status, whether or not they are eligible for Pell grants or the 21st Century scholarship program (both of which are indicators of financial need), and the number of hours worked per week.

Frequency of Use

Survey respondents were asked about the frequency of their use of their mobile devices for academic activities. Of students who own a smart phone (n=889), 54.3% reported they used the device once per day or more, with an additional 23.8% that noted they used the device several times per week. Students who own laptops (n=838) reported heavy usage: 80.3% use their laptop once per day or more, with an additional 16.6% using them several times per week. Students who own tablets (n=324) had less usage; just 39.8% used the device once per day or more and 19.8% used a tablet several times per week.

Number of Screens Used for Academic Activities

The number of screens used by a student while conducting academic work was a frequent refrain during the focus groups. Survey respondents were asked to report the number of monitors they use with their laptop, Chromebook, or desktop computers. Interestingly, 76.5% of students who own laptops reported having no external monitor (thus relying on the laptop's screen alone). Just 20.0% of students who own laptops use one external monitor and the remainder (3.5%) report using two or more. A single monitor was used by 55.9% of desktop computer users, with an additional 38.0% using two monitors. The majority of students (87.2%) who use a Chromebook as their primary computing device did not have an external monitor. The total number of monitors and mobile device screens was calculated for each student. Of the 2,026 students who reported owning a smart phone, 41.8% have two

screens (one of which is their smart phone) available to them and 1.5% have just one – which is their smart phone.

Applications Installed on Smart Phones

Students were asked to select the apps related to academic work that they have installed on their smart phones. The complete list of apps offered in the survey can be found in Appendix H – Applications Available to be Installed on Student Mobile Devices on page 142. The three most popular apps installed by students who own smart phones (n=1,982) were Canvas Student (82.1%), Zoom (78.4%), and Google Drive (74.9%). The three apps that were installed the least were VoiceThread (1.6%), Unizin Read (2.3%), and Boost (8.9%). Individual apps by Google – such as Docs (69.6%), Sheets (37.0%), and Slides (39.4%) – were more popular than their Microsoft counterparts: Word (30.0%), Excel (20.5%), and PowerPoint (20.6%).

Research Question 1: What types of academic work do students want to perform on their mobile devices at a large public university?

Students who owned smart phones were provided with a list of 29 different academic activities that are possible to perform on a smart phone. These activities were divided into groups aligned with the transactional distance of the activity for later analysis, as denoted in Appendix I – Academic Activities Classified According to Park's Pedagogical Framework on page 142. The students were able to select from four responses for each listed activity: "I do this," "I'd like to do this," "I didn't know I could do this," and "I won't do this."

Three of the four most popular academic activities for students to perform on their smart phones were all classified as Type 2 activities according to the Park framework (2011), as described in

Table 3. Type 2 activities are those that are classified as having a higher transactional distance and little direct interaction with the instructor, as described on page 28. Those activities include reviewing grades (86.4% of students noted that they "do this"), viewing course announcements (85.8%), and reviewing due dates (84.0%). The survey results are supported by open-ended comments from students in the survey and the focus groups. As one student noted: "Most of the time I use my laptop or desktop when checking Canvas, but I use my phone for push notifications and to check grades when away from my computer. It is pretty handy being able to use Canvas from my phone." A second student states: "Getting notifications (is) great because I can check grades easily when they can come in and can respond to professors quickly."

Further, three additional academic activities classified as Type 2 were identified by students as activities they would *like* to perform on their smart phones. These activities are classified as instructional tasks involved in the delivery of learning resources, including listening to an assigned podcast or audio recording (50% of students report that they do this, and an additional 23.1% of students would like to do this), watch assigned videos (47.5% do this; 16.2% would like to do this), and read or reference their textbook (28.7% do this; 14.1% would like to do this).

Support for audio-based resources is echoed in feedback directly from students in statements such as "I listen to podcasts all the time, though I've never had a class assign one" and "It would be a lot easier if I could access more media from my phone in case I can't get to my laptop." One student participating in the focus group simply stated, "I would kill for an audio version of my textbook." Students also reported transforming other course resources into audio for their convenience. For example, a student completing a doctorate in social work shared that she uploads PDF files "…into an app called Speechify that I can hear the audio readings from so I can listen to the readings while I'm driving during my commute." Several students who participated in the focus group reported that they would play the audio from recordings of classroom sessions in the background while studying.

Students reported very little interest in performing academic activities classified as Type 4 in the Park framework with their smart phones. These can be considered learning activities and are those that have a low transactional distance (which may include being in the classroom with the instructor) but are also individualized, as described on page 29. The activities that students performed *least* on their smart phones include writing an academic paper (6.9% report that they do this; 88.3% of students report that they would not), taking an exam (7.0% report that they do this; 85.9% report that they would not), writing a short essay (11.7% report that they do this; 81.7% report that they do not), and take notes (13.5% report that they do this; 75.4% report that they do not).

Students who own tablets were asked about their use of that device for academic work for a small subset of the activities. The act of taking notes was more popular with students who use tablets (48.8%) than those who use smart phones (13.5%). A survey respondent who owns a tablet stated one specific benefit: “Using a tablet allows me to take notes directly on provided materials which limits the amount of repeat information I cover.”

Demographic Influence on Preferred Academic Activities

Differences in the use of smart phones for academic activities emerged in multiple demographic categories related to student classification (undergraduate vs. graduate), enrollment status (full time vs. part time), and Pell grant eligibility (which is a used as a measure of students in need of financial assistance).

Undergraduate students use their smart phones more frequently for Type 2 activities than graduate students. A chi-square test of independence was performed to assess the relationship between each the three most popular academic activities and student classification. There was a significant relationship between student classification and viewing grades: $X^2(3, N=853) = 94.40$, $p < .001$. Another significant relationship between student classification and viewing course announcements also exists: $X^2(3, N=853) = 44.74$, $p < .001$, as does a significant relationship between student

classification and reviewing due dates: $X^2(3, N=853) = 104.22$, $p < .001$. Undergraduate students and graduate students agreed that they would generally not wish to engage in Type 4 activities, although a chi-square test of independence showed that undergraduates were slightly more willing to write an essay using a smart phone than their graduate counterparts: $X^2(3, N=853) = 8.23$, $p = .041$.

Similar distinctions were found between students who are enrolled full-time vs. those who are enrolled part-time. Chi-square tests of independence support the finding that full-time students are more likely to engage in academic activities with their smart phones than students who are enrolled part-time. A significant relationship between enrollment status and viewing grades was found, $X^2(3, N=885) = 58.08$, $p < .001$, as was a relationship between enrollment status and viewing course announcements: $X^2(3, N=885) = 31.51$, $p < .001$. Full-time students were more likely to use their smart phone to review due dates as well: $X^2(3, N=885) = 43.37$, $p < .001$. It should be noted that part-time students more frequently responded "I'd like to do this" to the Type 2 academic activities than did full-time students. For example, 13.8% of part-time students stated that they would "like to" review grades, while just 4.4% of full-time students said the same. Only 69.1% of part-time students reported that they "do" review grades on their smart phone, while 90.8% of full-time students engage in this activity. Similarly, only 68.0% of part-time students noted that they review due dates using their smart phone but an additional 16.0% reported that they would like to. Contrast this with the 88.1% of full-time students who do review due dates, with only 5.8% reported that they would like to.

Examination of the academic activity preferences of students who are eligible for Pell grants shows several differences in the use of their smart phones when compared to their peers. Chi square independence tests for independence show that the behavior of students eligible for Pell grants is statistically significantly different from their peers in 18 of the 29 specific academic activities in the survey, including five of the six Type 4 academic activities that were generally rebuffed by the full survey population. A comparison of these outcomes can be found in

Table 3 below.

Table 3
Comparison of academic activities performed via smart phone by Pell-eligible and non-Pell-Eligible students (indicates statistical significance)*

Academic Activity	Park's Type Classification	Pell-Eligible Students Who "Do This"	Non-Pell Eligible Students Who "Do This"
Read or reference notes/handouts*	1	52.3%	42.0%
Read Canvas pages*	1	65.5%	56.9%
Watch classroom recording	1	43.3%	36.8%
Send or respond to Canvas inbox w/ instructor*	1	87.7%	71.3%
Send or respond to HU email w/ instructor	1	89.0%	84.3%
Send or respond to direct message w/ instructor*	1	78.4%	71.4%
Send or respond to text message w/ instructor	1	59.5%	55.9%
Participate in a graded discussion exercise*	1	51.0%	35.3%
View course announcements*	2	91.6%	84.28%
View Canvas calendar*	2	78.8%	65.0%
View Canvas to-do list*	2	86.0%	68.8%
View course roster*	2	55.1%	51.2%
View push notifications	2	76.5%	74.0%
Review assignment requirements*	2	81.4%	73.9%
Review due dates*	2	92.2%	81.9%
Review grades*	2	92.2%	84.8%
Read or reference textbook*	2	36.5%	26.7%
Watch assigned video	2	52.3%	46.3%
Record introductory video	2	48.8%	34.1%
Listen to assigned podcast/audio	2	54.0%	49.0%
Take photos of whiteboards or class activities	3	76.7%	69.1%
Take video of whiteboards or class activities	3	38.7%	33.1%
Make audio recording of lecture or class activity	3	19.6%	20.6%
Take notes*	4	19.0%	12.2%
Take photos of course materials	4	77.3%	71.0%
Take a short quiz*	4	47.9%	35.8%
Write a short essay*	4	21.5%	9.3%
Take an exam*	4	9.8%	6.3%
Write an academic paper*	4	10.4%	6.0%

Pell-eligible students were more likely to review their grades with their smart phone, as measured in a chi squared independence test: $X^2(3, N=885) = 9.27$, $p = .026$. They were also more likely

to view course announcements (X^2(3, N=885) = 8.80, p = .032) and review due dates (X^2(3, N=885) = 13.52, p = .004).

These differences persisted when examining Type 4 activities, which have a low transactional distance but are highly individualized. Pell-eligible students appeared far more likely to perform summative assessments with their smart phones than did students who were not Pell-eligible. For example, 47.9% of Pell-eligible students use their smart phones to take a short quiz whereas 35.8% of non-Pell-eligible students did the same. This was confirmed by a chi squared independence test that showed a statistically significant difference between the groups: X^2(3, N=812) = 9.00, p = .029. A stronger correlation was found between Pell-eligible students who use their smart phones to write a short essay, X^2(3, N=811) = 19.89, p < .001. Statistically significant relationships between Pell eligibility and the use of a smart phone to take an exam (X^2(3, N=812) = 7.85, p = .049) and write an academic paper (X^2(3, N=812) = 8.04, p = .045) were also found and demonstrate that Pell-eligible students are more likely to take exams and write papers on their smart phones than students who do not qualify for Pell grants.

Comparison of Instructional Tasks Associated with Learning Materials

The 29 academic activities can each also be classified into one of the four academic activity types related to the specific content or function performed in each, as discussed previously on page 15. Those four activity types include **instructional tasks** (any activity that involves reading or otherwise consuming learning materials provided by the instructor), **learning activities** (the creation of artifacts related to learning, such as assessments or notes), **communication and interaction** (interactions with the instructor or the receipt of information related to the class, such as announcements or grades), and **recording** (the preservation of artifacts created during the learning process). The activities that students engaged in most with their smart phones fall into the category of communication and interaction – such as course announcements and reviewing grades. The activities students performed the least were those

in the learning activities category – including writing papers and taking exams. Students who responded to the survey were divided about the use of their smart phones for the completion of instructional tasks – specifically, the consumption of learning materials. These divisions were discussed frequently in the focus groups as well; thus, it is important to analyze the specific activities related to these instructional tasks and examine the student experience of doing so in the context of their smart phones.

Six of the 29 academic activities fall into the category of instructional tasks. Those activities include read or reference notes/handouts from the instructor, read Canvas pages, watch a classroom recording, read or reference an assigned textbook, watch an assigned video, or listen to an assigned podcast or other audio. The survey asked the participants to rate each activity in one of four categories: "I do this," "I'd like to do this," "I didn't know I could do this," or "I won't do this." The most commonly performed instructional task performed on a smart phone was to read Canvas pages (58.7% of students reported that they do this) and the least performed was to read or reference an assigned textbook (28.7% of students do this). However, when the response rate for "I do this" and "I'd like to do this" are combined, they exceed the rating for "I won't do this" in five of the six measures, as demonstrated in Table 4. The only instructional task that more than half of students stated that they "won't do" is to read or reference an assigned textbook. Given that all six of these instructional tasks are technologically able to be performed on a smart phone, the number of students who report that they would like to do them may be important.

Table 4
Student willingness to perform instructional tasks on a smart phone (n=883)

Instructional Task	**Students Who "Do This"**	**Students Who "Would Like to Do This"**	**Students Who "Won't Do This"**
Read or reference notes/handouts	44.2%	16.2%	37.7%
Read Canvas pages	58.7%	10.9%	28.8%
Watch classroom recording	38.1%	15.5%	43.2%
Read or reference textbook	28.7%	14.1%	54.6%
Watch assigned video	47.5%	16.2%	35.2%
Listen to assigned podcast/audio	49.9%	23.1%	23.6%

As in the examination of all 29 academic activities, there were some statistically significant differences in the performance of instructional tasks between some demographic groups. Chi squared independence tests demonstrate that undergraduate students were more likely to use their smart phone to perform five of the six instructional tasks, including read or reference notes/handouts (X^2(3, N=850) = 17.36, p = .001), read Canvas pages (X^2(3, N=848) = 23.38, p < .001), watch classroom recordings (X^2(3, N=850) = 7.93, p = .048), watch assigned video (X^2(3, N=848) = 14.61, p = .002), and listen to assigned podcast/audio (X^2(3, N=844) = 10.08, p = .018). Pell-eligible students were more likely to use their smart phones to perform instructional tasks related to reading than their peers. Chi squared independence tests show that Pell-eligible students used their smart phones more often to read or reference notes/handouts (X^2(3, N=882) = 21.8, p < .001), read Canvas pages (X^2(3, N=880) = 11.50, p = .009), and read or reference their textbook (X^2(3, N=883) = 18.87, p = .001). Note that the survey respondents as a whole had the least desire to read or reference their textbook on their smart phone, yet this task was performed at higher rate for Pell-eligible students.

The number of screens available to students also shows some influence on the performance of instructional tasks related to reading. Of students who have just one screen available (meaning, a smart phone but no laptop, Chromebook, tablet, or desktop computer), 52.2% report that they read or reference their textbook via their smart phone, whereas only 28% of students with two or more screens do so. And 75% of students with one screen read Canvas pages when 58% of students with two or more screens do the same.

Research Question 2: What barriers do students encounter when using their mobile devices for formal learning at a large public university?

The results for the previous research question reveal that the students are divided in their desire to use their mobile devices for academic activities – some are either in favor or dependent on mobile devices (or both), and others demonstrate little willingness to engage in these activities on

devices other than a desktop or laptop computer. This section attempts to shed light on the specific barriers that students feel prevent them from engaging in academic activities on a mobile device.

Students who responded to the survey were asked to select all the possible "…conditions (that) have prevented you from using your smart phone for academic work." The list of possibilities included factors related to the physical design of the devices, their connectivity, and the design and features of the applications used on the devices. Two specific barriers were noted by a majority of the students. Over 85% of students (n=803) selected "Small screen size" as a barrier to doing more academic work, particularly instructional tasks, on their mobile device. But 78.1% also noted that the mobile applications have "(l)ess functionality than the desktop/laptop version." Therefore, it appears that students' perceived barriers to the use of their mobile devices is due to both physical as well as software design factors. However, the students also mentioned several other considerations that are worth understanding.

Physical Constraints: Screen Size and Keyboard Input

As noted, the vast majority of students (85.4%, n=803) selected screen size as a barrier to using their mobile device for academic activity. This challenge was not, however, the only physical constraint that was mentioned as a barrier by students. Students also noted that they were impeded because they could not access the content or application (33.0%), could not use documents with fixed font size (27.7%), and could not rotate the screen to their preferred layout (24.7%). Open-ended comments by the students supported the notion that the screen size was not ideal for academic work when other options were available, and that this was generally just a preference on their part. This is summarized by one student, who stated they "(d)on't use the small screen much. I just prefer using a big monitor for doing my work and assignments." Another student noted: "I just do not like using such a small screen for stuff, and I am not able to take notes on my phone at the same time as doing work, so I prefer my laptop." A student simply said: "I would rather use my computer. Why work on a small screen if I don't

have to?" Other students noted specific impediments, such as "…hard to read PDFs on a smart phone" and "…interpreting diagrams or teacher notes the screen would be too small for me."

Many students noted that reading, in particular, on a mobile device was too physically challenging on the eyes. This issue was mentioned by students who have physical impairments, as in "(r)eading is difficult for me on a small screen due to poor eyesight," and "I cannot read much on a smartphone – too hard to read with my vision." But many students made similar comments unrelated to specifical physical concerns – they simply find reading on a smart phone to be challenging. Several statements from students support this idea, including "I try not to use my smart phone for reading because it is so hard on my eyes," "There is much more strain on my eyes when reading or writing large portions of text on a phone compared to a laptop, likely due to the restricted screen size," and "(e-texts are) convenient to search through and usually cheaper, but part of me is just sick of looking at screens all day. It gets hard on the eyes after a while."

Many comments by students focused on the negative impact of reading on screens in general – not just on the smaller screens consistent with mobile devices. Many students who responded to the survey expressed a strong preference for physical books: 69.3% of students (n=966) stated that they prefer physical books when reading for pleasure, and 45.9% of respondents (a plurality) stated that they prefer physical books for academic reading. Approximately one third of students (34.0%) selected "laptop/desktop" as their preferred reading option for academic texts. The appeal of physical books was mentioned in many statements by students, such as "I am one of those people who cannot read off screens. I need physical books. I can save my spot on the book, not strain my eyes, and carry it around with me wherever I go." Students also shared that physical books were less tiring to read: "It is less tiring to read paper books than books on a screen," and "I feel like I already use my laptop so much for assignments that I would rather read physical textbooks rather than the e-texts to give my eyes a break."

Reading, an instructional task with high transactional distance, was not the only academic activity that students felt was impeded when using mobile devices for academic work. Students also reported that the physical constraints of mobile devices – specifically the small keyboard and lack of mouse control – made it difficult for them to engage in learning activities as well. Some students noted that this was primarily a preference on their part. One student bluntly stated, "It sucks to type on a phone when you're doing any type of writing (discussion post, essay, etc.)." Another student astutely challenged the author of the survey in her response:

> It's just very clunky to do extended work on a phone as opposed to a desktop. My hands aren't that small, writing more than a paragraph would just be impractical and painful. It is easier to multitask on a full machine. Did you write this survey on your phone? Qualtrics on the go?

However, several students noted that providing input on a mobile device could, in fact, negatively impact their academic performance. For example, "I think it's a bad idea since it's easy to make errors on such a small device." Another student stated that the "(a)bility to type is easier (more professional) on a computer. More confident in a computer," and another referred to their entire suite of tools used while engaging in a learning activity: "My reference tools for assignments remain the laptop and desktop. The smartphone is too small. I cannot use the keyboard without making a lot of errors while editing. I'm going to lose time with it."

The Need for Multitasking

Almost half (47.8%) of the students who responded to the survey (n=803) reported that one barrier to using their mobile device for academic work was that there was "too much information on one screen." This concept was noted repeatedly throughout the open-ended comments in the survey and was a topic of discussion in each of the focus groups as well. Because so many instructional tasks are delivered as digital media (such as e-texts, handouts and presentations, and videos), students report a situation where they need to have multiple digital sources available simultaneously. This results in

statements such as: “I like to have multiple tabs and windows open on my laptop,” and “I use my laptop or desktop computer. Because of my additional monitors on both, it is much easier to complete assignments on those platforms.”

However, as stated previously, 76.5% of students who own laptops do not have an external monitor and 55.9% of desktop computer users have a single monitor. Therefore, students frequently reported the necessity of having multiple digital resources available at the same time. As one student noted, “I usually prefer to use my computer when reading or watching materials because of the size of the screen and access to multitasking (i.e., watching a pre-recorded lecture or video and taking notes on word at the same time).” This situation can also an impediment for online courses, as reported by one student: “Online classes are frequently taken on a laptop so I cannot view the class and a full laptop screen at the same time.” One focus group participant noted that she prints pages from her digital textbook to use while performing a learning activity, rather than using a mobile device and “…having to scroll aggressively to get to (the content). It's so much harder than just flipping a bunch of books.” A student noted that she “…will stream a video from my phone onto the TV so I can use my laptop to take notes.” Another participant summed up his workflow for taking notes while watching an online course:

> One thing I don't like about having recorded audio videos on Canvas, I can't make it full screen within the Chrome browser. So, it has to always be full screen on the entire monitor. It's hard for me to split screen and take notes. But usually what I do is have half of the screen of the video and then in the other half, I'll take notes.

Tablets

Several students reported that their use of a tablet (such as an iPad or Samsung Galaxy device) was preferable to working on a smart phone and that the larger size and increased capabilities of the tablets ameliorated some of the barriers when engaging in academic work. This was particularly the case with instructional tasks, where students stated that “…a tablet is useful to read ebook, while the smart

phone is a little inconvenient due to the small screen," and when reading a digital text that "…something the size of an e-reader might work." Focus group participants who owned tablets agreed that they are far more likely to read on a tablet, but not a phone. Students also felt that the larger screen of the tablet allowed them to view video content at an acceptable size, as in: "I like to watch lectures or videos on my tablet rather than my phone." One student reported that they felt the tablet was a more natural mechanism to perform instructional tasks:

> I really like it! In the beginning, I felt like I was not retaining what I read when it was in electronic format. But since I have started to use an iPad, I really enjoy reading texts on there. I am able to highlight, underline, annotate, and even write down summaries or questions as they come up.

The use of tablets was also mentioned frequently in the context of learning activities, most often taking notes (which was rarely done by students using smart phones). "I use the notability app on my tablet, it makes note taking easier and more organized," said one student in the survey. Another stated that "iPad is like a notebook but it can have everything on it, and I can access it from my laptop or phone if I really need to. Also, taking photos of the boards or lectures is useful when professors are going too quick." One student simply summarized that "(m)y iPad and Apple Pencil are now my essential note-taking tools for all my classes."

Lack of access to tablets was referenced as a concern by a few students. Focus group participants related that the most important devices to purchase were phones and laptops, and that the tablet appeared to be an ancillary device or was something with which they were just not familiar. One focus group participant simply stated that a tablet "…is a lot of money to spend just to see if I like it." Still, they were curious about the additional capabilities, as in one statement: "I don't like to type my notes and I am only able to write with pen and paper…. If I had an iPad, I would probably use that." Focus group participants that did not own tablets did recognize their benefits. Said one:

> I personally would probably use it – just because I like to actually write stuff down. And that gives me the option to do that. But if I had a stylus and could write quickly, and diagram, probably, I'd give it a shot. I've never used one, so I don't know how well it works.

A survey respondent had similar feedback:

> I think I would have used tablets to take notes since they have a larger screen. Still, I guess I am used to typing on the keyboard and, thus, it is faster for me to take notes via keyboard rather than hand. So I guess I would still stick to my laptop (or maybe this is due to me not trying tablets :/).

Technological Limitations of Hardware and Connectivity

Students also identified issues with using mobile devices for academic work beyond their physical design constraints. “Bad WiFi or connectivity” was cited as a barrier by 26.5% of survey respondents, and was a common refrain in the open-ended survey comments such as: “The wifi at (HU) seldom works for me or any of my friends so we don't use it,” “the wifi was not good enough in the science building for my phone or laptop to connect,” and “bad university wifi, namely eduroam, has prevented me from doing necessary work on campus multiple times this semester.” A survey respondent stated that they preferred digital materials but referenced that they were dependent on connectivity: “…anything on a tablet or computer is better than paper. As long as the wifi works!”

Students also reported less trust in their smart phones than in other mobile devices to perform academic work. One student noted that “I do not trust using my phone for anything important that could heavily affect my grade, as I've said, I trust my computer so much more and it is much more efficient than a phone.” Another stated: “I do not use canvas on my phone to submit assignments as I do not trust my phone,” and “(s)ometimes phones break easily, and sometimes data gets full and it won't save things.” This feeling was neatly summed up by one survey respondent: “'Can you hear me now?'" is not just a jingle. Intermittent (signal)-loss, dropped calls/service etc. Lack of trust in both signal and

auto-correct incorrectly modifying complex language subject matter." Sometimes these concerns are related to the age of the device itself, as one student stated: "My phone is a bit old, so it dies randomly. This makes it not very desirable to use to complete coursework on." Yet another demonstrated the impact of poor connectivity and a device's age with the statement: "newer buildings (don't have) good service for providers (i.e., Verizon). Don't want to use up all my battery because I can't easily charge my phone."

Finally, students report that they frequently encounter issues related to data storage on their mobile devices, most often on their smart phones. This does not refer just to the actual academic files themselves, but the number and size of the apps required to perform academic work. A survey respondent noted: "…when it comes to dealing with files, my one of my biggest issues is, like, I need like another five apps on my cell phone just for school." Another student describes their workaround for this issue: "My phone has limited storage, so I usually access (HU) associated sites such as Canvas through the web rather than from an app." A focus group respondent quite passionately summarized her frustration with the sheer number of third-party applications students were expected to install to perform required academic work: "In my day to day, I'm constantly choosing what apps I'm going to delete in order to make room for other stuff."

Differences In Functionality Between Desktop and Mobile Technology

The second most-selected response to perceived barriers to the use of a smart phone for academic work by survey respondents was that the mobile experience provided "…less functionality than the desktop/laptop version." A majority of students (78.1%) stated that they had experienced this issue. The students' experience with Canvas was a particular point of discussion for both survey respondents and focus group participants. One student simply noted that: "Canvas's current design seems to be trying to work for both computers and phones at the same time but doesn't really work for

either." There were concerns with the ability to find specific items on mobile devices in the same manner as in the desktop version, such as: "It doesn't have filters so viewing assignments is frustrating."

Other functionality deemed critical by students is simply absent from the Canvas mobile app. Students noted that they cannot view student groups on mobile devices: "On a smartphone, Canvas will not show groups that you are a part of in a class" and "Smart phone doesn't seem to work with Canvas groups - I can only use them on a PC/Laptop." Students also shared that they are unable to view feedback from their assignments in a readable fashion, if at all. One survey respondent stated: "You can't always see comments and feedback on a smart phone, which is frustrating when wifi isn't available or I don't have my laptop but still need to look at things" and "I have trouble seeing feedback on assignments with my smart phone." Another noted that an important feedback tool was not as easy to use on the smart phone as on the desktop: "Rubrics are very difficult to interface with in the mobile app. They are rather difficult to read the way they are laid out." The mobile version of the Canvas calendar was specifically noted as troublesome: "The canvas calendar does not function properly" and "The calendar is not easy to view on mobile." One student stated that "I have missed important information when using the app that I later saw via web browser." Finally, the navigation through the application was identified by survey respondents as a concern: "The mobile version is way more of a pain than using desktop. Desktop has normal navigation menu on side of screen, while mobile requires a dropdown box that fills entire screen." It is understandable why students would mention specific concerns with Canvas functionality; it appears that the Canvas implementation of two of the top three academic activities performed by students with mobile devices – reviewing due dates (i.e., the Canvas Calendar) and reviewing grades – is quite different in its desktop and mobile implementations.

Students also expressed concerns with content posted in various platforms and noted that the content was often cut off or otherwise incomplete when viewed on a mobile device. Focus group participants noted that they appreciate it when instructors post PowerPoint files related to classroom

activities or lectures, to aid in studying as well as notetaking. However, “Sometimes the power-points *[sic]* posted in Canvas do not show all of the material when opened on a mobile device.” Other content embedded into course pages can cause similar issues: “It generally works well, but sometimes the screen doesn't allow me to see everything that is there, especially when Pearson homework assignments are embedded into the Modules section of Canvas.”

Varied Platforms and User Experiences

Another barrier to the use of mobile devices for academic work came in the form of the vastly different user experience between working in a traditional Web browser, as on a laptop or desktop computer, and the experience of being moved between different mobile apps on a smart phone or tablet. Often, a student will have to authenticate themselves once (or more) for each app in use – which is complicated by the two-factor authentication (Duo) in use at Hudson University. One survey respondent neatly summarized some of the practical impact this has on students:

> Modern browsers are blocking a lot of the cookies that the university uses to move people between apps. Whenever I use the one app, I need to log in, then every app I launch, I need to log in again with the Duo mobile authentication app. It's miserable so I only use things when I have to.

Another survey respondent expressed similar frustration:

> Doing Double Authentication every time I open the website in my browser (even multiple times in the same day) is too much effort. The (Canvas) app keeps me logged in at least, but I prefer the Canvas layout in browsers.

Another student who preferred the Canvas Web interface on a mobile device over the Canvas app stated: “Having to re-login every time I want to see Canvas takes too long and often I find myself exiting the app because I don’t have the time to wait that long.”

Another frequent student complaint was that when using a mobile device, they do not always get to choose which application is launched when an action is performed. A survey respondent noted that “I can’t open links from emails in the canvas app; the links open in my browser.” This can lead to frustration from students who, as noted, can already be overwhelmed by the number of apps they are asked to install.

Viewing Academic Video

Students report that they watch video for leisure with their smart phones significantly more than they watch video related to academic work. Over 83% of students who own smart phones report using those devices to watch non-academic video, but just 36.3% of students report using their smart phones to watch video for school. Part of this discrepancy is simply due to the physical dimensions of the phone, as previously discussed. However, both survey respondents and focus group participants reported that there were several differences in the software used to play back academic recordings when compared to reviewing video for leisure. Focus group participants noted that the Kaltura video platform in use at Hudson University lacked very specific functionality that would improve their experience. Many students made direct comparisons to the Kaltura player and the player in the YouTube website and the YouTube mobile application. Said one student, “for example, it's the difference of watching YouTube on the YouTube app or watching YouTube, like, by going into your (browser) and then watching it – it’s just WAY less user friendly, so I don't do it.”

Specifically, students noted that there was no mechanism to quickly skip forward or backward for a fixed number of seconds and an inconsistent ability to adjust the playback speed of a Kaltura video that is embedded in a Canvas page. These features are important to students, as one study demonstrated that 85% of undergraduate students view academic video at speeds faster than normal (Murphy et al., 2021). There is also no ability to resize the video – it is either played at the size embedded by the instructor or instructional designer or viewed at full screen. This is particularly

bothersome to the students 76.5% of students who own laptops and 55.9% of students with desktop computers who are working with just one monitor. Students also noted that there is no ability to download a video file and play it in the application of their choice (which may afford some of the additional features they seek), the way they can choose which PDF reader they would like to open when working with a PDF file. On a mobile device, any Kaltura video embedded in Canvas can only be viewed in the Canvas website or Canvas Student app, thus depriving students of those common video playback features and potentially impeding them from viewing (or listening to) the video while simultaneously conducting another activity (such as notetaking).

Finally, some of the academic work students are expected to perform – both instructional tasks as well as learning activities – simply cannot be done on a mobile device. One student notes: “Most of the software needed for classes like Mcgraw Hill connect or mymathlab *[sic]* do not work on my phone.”

Distractions Associated with Mobile Devices

Students noted that because they use their mobile devices for both personal as well as academic use, they sometimes have difficulty narrowing their focus to the task at hand because it is very easy to become distracted. This sentiment appears particularly potent with smart phones, as stated by one student who responded to the survey: “My smartphone is typically used for stuff outside of school, so it feels distracting and not as productive using my phone for school activities.” Other students stated that they sometimes physically distance themselves from their smart phones in order to engage with academic work. “I put (my smart phone) away so that I can engage in deep work,” stated one student, while another noted: “I have too many notifications and distractions already on the phone; when I do academic work I like to be in the right headspace and sit down in a focused setting with my laptop and do work.” Another survey respondent noted: “Perhaps another aspect to my limited use of my smart phone for academic work is that I can get distracted by my social media apps and messages. Therefore, I like to use my phone less frequently when possible.” Some students seemed unaware of the smart

phones' built-in abilities to help them focus: "(if there) could there be an app that would make the phone only focus on tasks I want to do at a specific or timed time, then that would be great."

Many students reported a sense of futility when dealing specifically with notifications on their smart phones – to the point that some focus group participants were on the brink of exasperation. One student simply stated that "Notifications annoy me" and another used hyperbole when stating "…the less push notifications the better. Please…I have enough push notifications. I just want to see what time it is. I don't need to know what temperature my fridge is at." Students also feel frustrated at duplicate notifications, particularly related to the Canvas app on their smart phones. Multiple students relayed their experience of receiving multiple notifications for a single event, as described here: "I receive about 5 of the same notifications which get annoying. For example, I will receive a course announcement then I will get 5 notifications for that one announcement." They also expressed a desire to winnow the notifications that they do receive: "I wish there were a way to narrow what I want to see. Currently the app is all or nothing. If I could control notifications more granularly it would be more useful."

Once again, students noted a perceived difference in their behavior between tablets and smart phones. One student noted that having the two devices would allow them to make more of a distinction between personal and academic activities: "…if I had a tablet, and I didn't have Discord on it, or my text messages going through there, I think that would be totally fine. I just…I don't have one. I'm not really willing to drop the money on one just yet." A focus group participant relayed her experience of having an assigned iPad in her K-12 school and noted:

> Of course, it's really hard to apply the knowledge of middle school to a college setting, right? But it was really like, I felt like it was super nice, because that was just where all the class stuff was…it was really nice to have technology just for school.

Research Question 3: How does a student's learning behavior differ based on the device in use at a large public university?

Research Questions 1 and 2 have revealed that the students who participated in the surveys and focus groups exhibit differing behaviors when performing academic work based on the device in use and have demonstrated this behavior in a variety of ways. The data analyzed for those research questions has been purely self-reported – the students themselves have described their behaviors, preferences, and barriers. To answer Research Question 3, I chose to analyze *actual* student behavior so that I could compare the students' reported activities with what has actually occurred.

To do so, I obtained the raw Canvas log data generated with every interaction between a student and the Canvas Learning Management System for the Fall 2019 semester at all campuses of Hudson University. Fall 2019 was selected because it is the most recent full semester for which data is available prior to the disruptions caused by the COVID-19 pandemic. This resulted in a dataset 152,127,914 individual activities between students and the Canvas LMS. The data contains information on the activities of 89,534 different students participating in 56,052 Canvas course sites. Bear in mind, however, that a Canvas site is created for every unique class section in the Hudson University system, including laboratory courses, independent studies, and a number of other non-traditional courses. Therefore, it is certain that not all these individual Canvas course sites represent a standard academic course in the context of the description used in this study.

The user agent for each log entry was examined to determine the specific Web browser or application in use for each interaction with the LMS. Although students can access Canvas on a mobile device by either a mobile Web browser (i.e., Safari on an iPhone or iPad) or the Canvas Student app, for the purposes of this study all interactions that originated from a mobile device – either a smart phone or a tablet – were categorized as a "mobile activity." Any interaction that was not a mobile activity, then, was classified as a "desktop activity" (which includes interactions from laptop computers and Chromebooks).

The individual interactions were then grouped into sessions, where any activities by the same user on the same device in the same Canvas course counted as a single "session." A session was considered concluded after 25 minutes of inactivity or if the user moved into a different Canvas course site. This resulted in 31,183,203 individual user sessions, of which 23,595,344 (75.7%) originated on a desktop and 7,587,859 (24.3%) were from a mobile device. A limitation of this analysis is that only Canvas interactions *within a specific Canvas course site* are included in this dataset. Therefore, we can only examine interactions that students have made with a particular course and not any interactions with generalized Canvas utilities such as the Inbox, To Do List, or Calendar.

Of the 89,534 students, 93.5% used *both* a desktop *and* a mobile device to access the Canvas LMS at least once during the semester and 88.9% used a mobile device to access Canvas at least five times. Just 6.2% of students used a desktop alone for the entire semester, and 0.3% of students *only* accessed Canvas with a mobile device through the entire Fall 2019 semester.

Within the 83,743 students who used both desktop and mobile devices to access the Canvas LMS, 79,325 students (94.7%) had a longer average session time when using a desktop computer than a mobile device. This leaves 4,418 students (5.3%) who had a longer average session time when using a mobile device than they did when using a desktop computer.

The Influence of an Activity's Perceived Duration

In the survey and focus groups, several students related that their choice to use their smart phone for academic activity was directly related to the duration of the activity itself. The previously identified activities that were found to be the most popular involve the student checking in on a class or their activity within it – primarily instructional tasks that are classified as Type 2 activities by Park (2011). This is supported by repeated statements made by students in the survey and in focus groups. One student summed up the use of their smart phone as "…great for short and quick things, not anything

super important or long." Another student quantified their usage habit by stating "I mainly use it for stuff that takes less than 10 seconds. I don't do assignments or open up modules."

This finding is supported by analysis of the Canvas log data. The overall average session length for students who use a desktop computer to access the Canvas LMS is 6.95 minutes whereas the average session length on a mobile device is just 2.94 minutes. With the consideration that this data only records interactions with a specific Canvas course site, this indicates that students on mobile devices are engaging in shorter interactions with their courses than they do on the desktop. This aligns with the students' self-reported preference for instructional tasks – such as checking assignment requirements, due dates, and grades – rather than learning activities on mobile devices.

Demographic Differences in the Use of Mobile Devices

The average lengths of both desktop and mobile Canvas sessions were calculated for each student in the dataset. The students were then compared to determine if there were any differences in the length of either type of session between demographic subgroups.

Campus of Enrollment

All students at Hudson University, whether in an on-campus or an online program, are assigned to one of the seven campuses in the system. There is one core campus in a small metropolitan area, an urban campus located in the largest city in the state, and five regional campuses that are geographically distributed throughout the state. Therefore, it is impossible to separate students who are in traditional programs and students who are enrolled in completely online programs in this data.

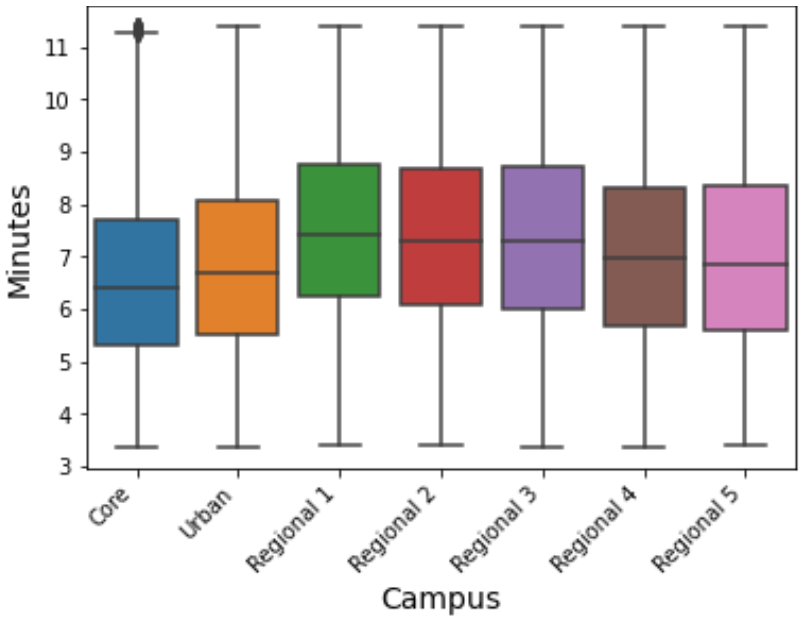
Examination of the number of Canvas sessions revealed that students from different campuses in the Hudson University system behaved differently when choosing to use a mobile device. A chi-square test of independence was performed to examine the relation between campus of enrollment and the number of Canvas sessions originating from a mobile device. The relation between these variables was significant, X^2 (6, N = 31183203) = 73474.2, p < .0001. Post hoc analysis shows that every pairwise

comparison of campuses reveals differing student behavior in the number of mobile sessions conducted and that students at four of the five regional campuses interact with Canvas using mobile devices more frequently than students at the urban and core campuses.

Differences in the length of Canvas sessions for students enrolled at the different Hudson University campuses were also found. The average session length per student on each campus is displayed in

Figure 4 (the top 5% and bottom 5% of results were trimmed to simplify the figure). A one-way ANOVA revealed that there was a statistically significant difference in the average length of a session conducted on a desktop computer ($F(6, 89527) = [380.75]$, $p < .001$) between students on different campuses. A post hoc Tukey test showed that the desktop session length at different campuses differed significantly at $p < .05$; only two of the regional campuses did not demonstrate a significant difference between them, whereas every other pairwise combination of campuses revealed a statistically significant difference. Students at the regional campuses tend to have a higher average Canvas session length when using a desktop computer than students at the core and urban campuses.

Figure 4
Average desktop Canvas session length by campus (trimmed)



The results of a one-way ANOVA examining the length of a session conducted on a mobile device was similarly statistically significant ($F(6, 89527) = [255.2]$, $p < .001$) and showed that students on various campuses used mobile devices to access Canvas differently. A figure displaying the trimmed values removing the outliers in the top and bottom 5% of the sample can be seen in

Figure 5. A post hoc Tukey test showed that the mobile session length at different campuses varied; however, they varied less so than desktop sessions. Significant differences were found in pairwise comparisons of all campus types; nevertheless, the regional campuses exhibited more similarities between them. Students at the regional campuses tended to have slightly higher average mobile session lengths than did students at the core or urban campuses, as seen in Figure 6. Therefore, students at the regional campuses appear to use their mobile devices both more frequently and for longer durations than their peers at the core and urban campuses.

Figure 5
Average mobile Canvas session length by campus (trimmed)

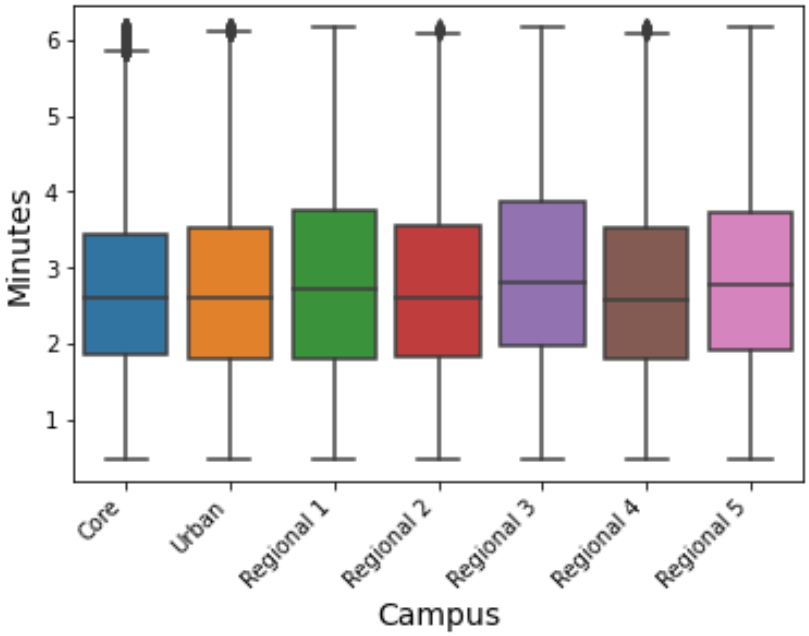
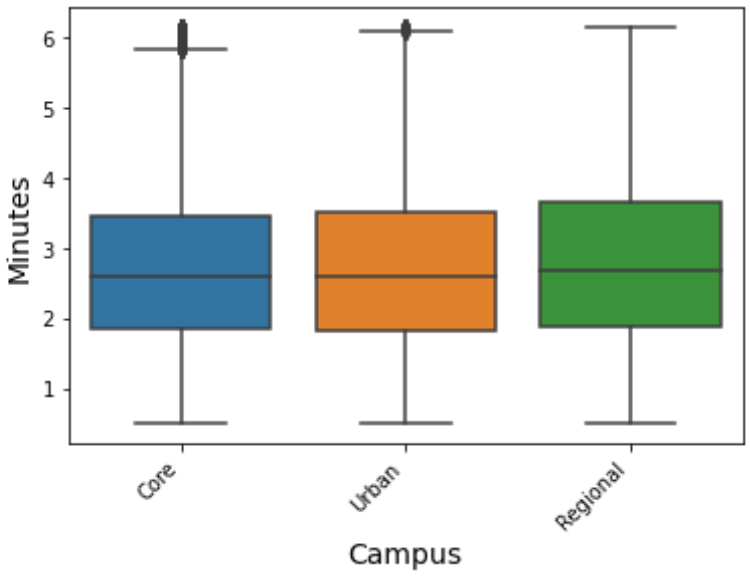


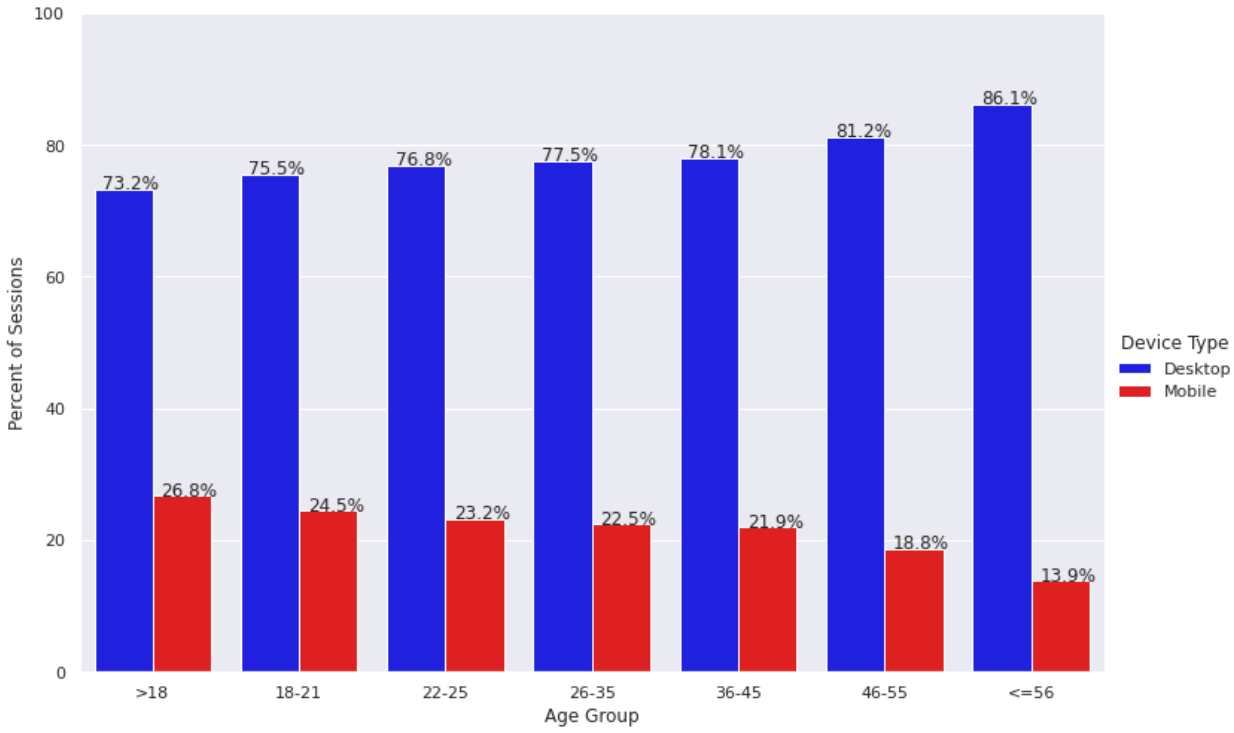
Figure 6
Average mobile Canvas session length by campus type (trimmed)



Age Group

The age group of the students was also found to predict the frequency of interaction with Canvas using a mobile device. A chi-square test of independence was performed to examine the relation between age group and the frequency of use of a mobile device to access Canvas. The relation between these variables was significant, X^2 (6, N = 31183203) = 22491.69, p < .0001. Younger students are more likely to use their mobile device to access Canvas, as demonstrated in Figure 7. Again, significant differences were found in every pairwise combination of age groups.

Figure 7
Percentage of Canvas sessions by device type and age group



Enrollment Status

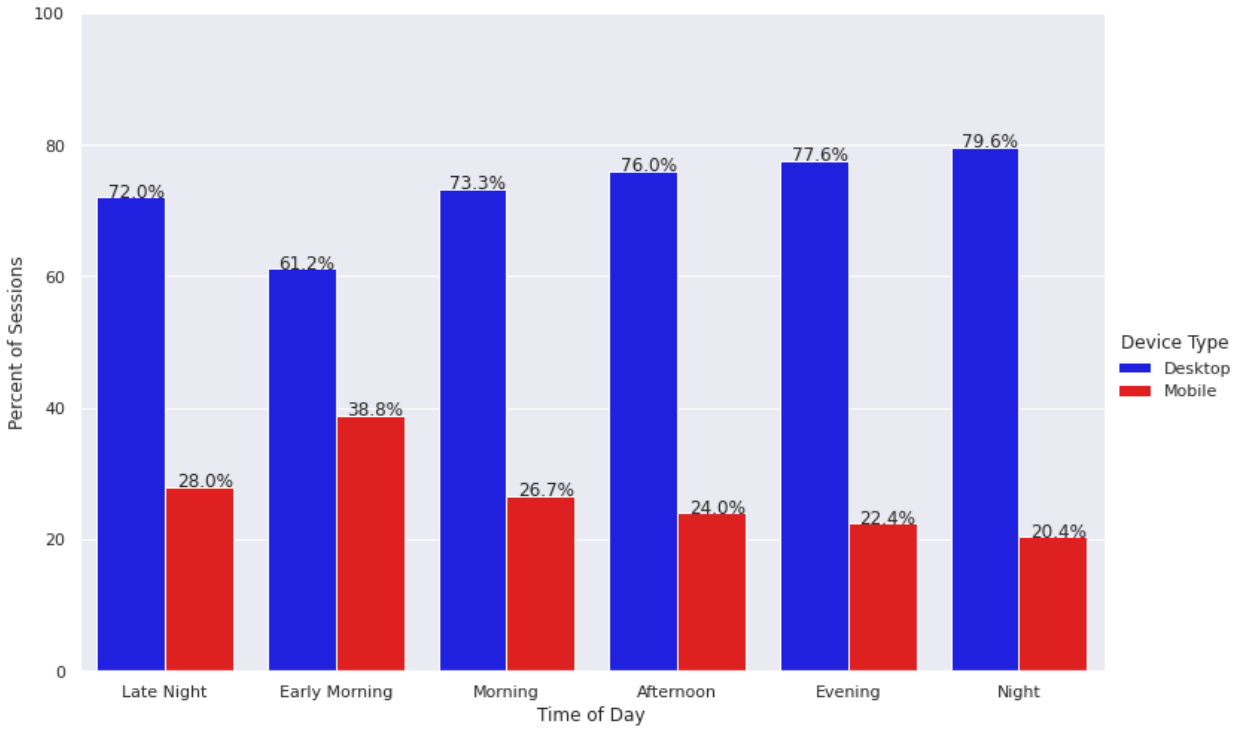
Students who were enrolled part time (less than 12 credit hours at Hudson University) were slightly, but statistically significantly more likely to use their mobile device to access Canvas. Full time students accessed Canvas from a mobile device for 23.9% of sessions and part time students used

mobile devices 24.4% of the time. This access data was found to be significant by a chi square test of independence X^2 (1, N = 31183203) = 472.65, p < .0001.

Time of Day of Session

Finally, although this is not strictly a demographic category, students were found to be more likely to use their mobile device to access the Canvas LMS in the overnight and morning hours than during the day, as seen in Figure 8. The most popular time of day to use Canvas with a mobile device was in the early morning (defined as 4am to 8am) – 38.8% of sessions during this time were on a mobile device. Late night (midnight to 4am) saw 28% of sessions on mobile, and 26.7% of morning (8am to noon) sessions were on a mobile device. This difference was once again confirmed by a chi square test of independence X^2 (5, N = 31183203) = 169302.15, p < .0001. It should be noted that all of the Canvas events are recorded in the time zone of Hudson University and not the physical location of the student.

Figure 8
Percent of Canvas sessions by device type and time of day



Entry Points to the Learning Management System

Students displayed a difference in their navigation through the Canvas LMS depending on the type of device used to access the site. The three most common entry points for a session that takes place on a mobile device are the course home page (26.4%), course assignments page (22.3%), and a page containing an individual assignment (13.3%). The three most common entry points for a session by students who access Canvas on a desktop device are an individual assignment page (12.8%), an attachment in Canvas (12.6%), and the course home page (12.5%).

The difference between the two platforms could be due to an interface design discrepancy between the desktop and mobile versions of Canvas. Students who participated in the survey and focus groups repeatedly emphasized their dependence on the To Do list and calendar functionality built into Canvas. In the desktop version of the application, the To Do list is presented on the first page displayed after successfully logging in, alongside the list of courses bookmarked by the student, as seen in

Figure 9. The Canvas Student mobile app does not present the To Do list on the landing page; rather, access to it is via a tab in the tab bar navigation at the bottom of the screen as seen in Figure 10. Students using the mobile application may be unaware of the ability to navigate directly to the To Do list and instead navigate to the information they seek by going to the course home page, into the assignments page, and then into an individual assignment whereas students using the desktop site can bypass extra navigation and proceed directly to an assignment's page from the To Do list presented on the landing page. More study is needed to determine the precise navigation pathways students use on the desktop and mobile versions of the Canvas application.

Figure 9
Home page layout of the desktop version of Canvas

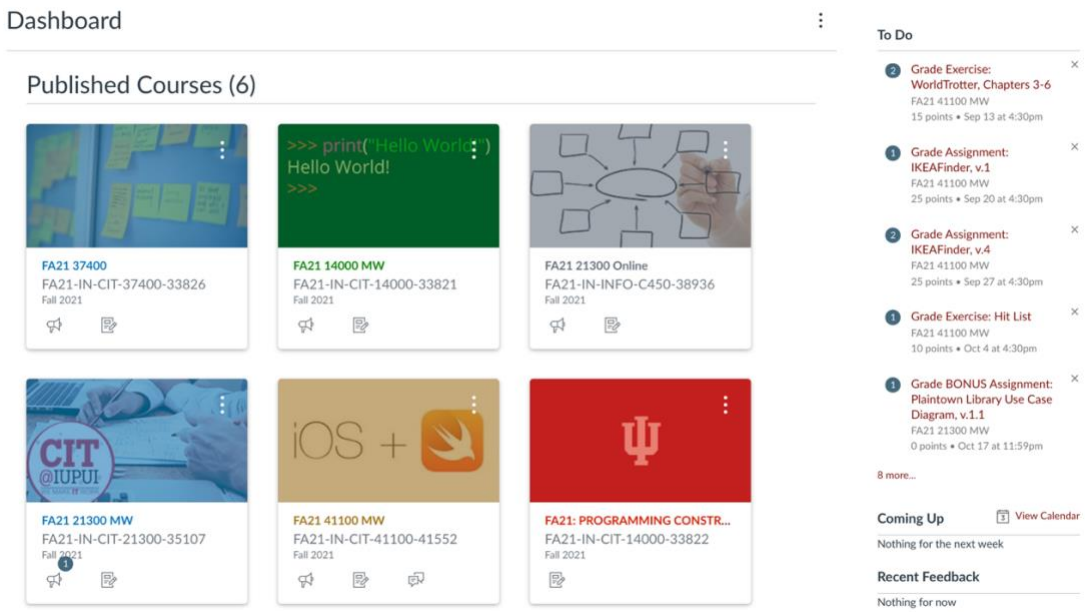
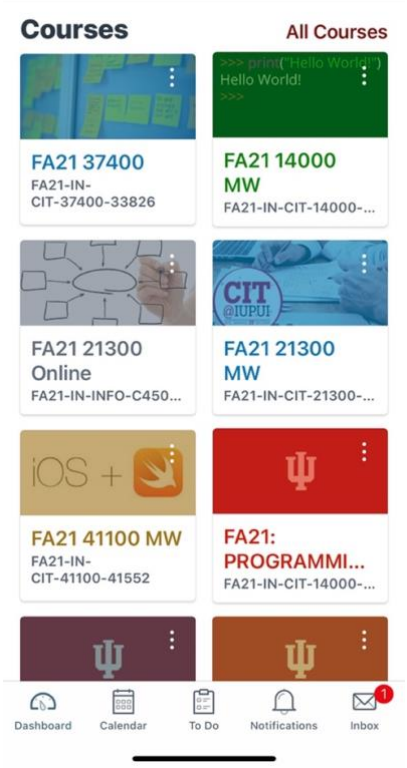


Figure 10
Home page layout of the Canvas Student mobile application



Viewing the details of an individual assignment is a common initial entry point for both desktop and mobile sessions. Desktop users view the details for an assignment as the first event in a session 12.8% of the time. Mobile users start 13.3% of their sessions by viewing the details for a specific assignment.

Reading course announcements was cited by students as a common use for Canvas app on mobile devices. However, less than 1% of mobile Canvas sessions begin by reading a course announcement, whereas an announcement is the entry point for 3.4% of desktop sessions. This difference could mean that students do not interact with push notifications for course announcements, or that interacting with a notification does not deliver students directly to the announcement on a mobile device. More research is needed to determine how this series of interactions is logged by Canvas.

Frequency of Canvas Activities by Platform

If we include our examination of activities performed in Canvas at any point in a session (rather than just the first activity in a session), more differences between desktop and mobile users appear. The three most common activities in Canvas for mobile users are viewing the details of a specific assignment (19.7% of all Canvas activities), viewing the course home page (18.5%), and viewing a course assignments list (14.6%). The three most common activities in Canvas for desktop users are viewing attachments (external files delivered to students via the Canvas LMS) at 23.5%, viewing an assignment's details (11.7%), and viewing a discussion topic (9.8%).

Attachments appear to be an important component to a student's interaction with Canvas. Almost a quarter of *all* activities in Canvas performed by desktop users involve the download or reading of attachments. However, this represents only 5.2% of the activity performed by students using mobile devices. It is not known if this is because the attachments are unavailable to students on the mobile device or if students simply choose not to view them while on their device. This result corresponds with

student's self-reported difficulty in viewing external files on their mobile devices due to screen size, viewability, and storage limitations. It is also worthwhile to note that students appear to heavily use the instructional resources that are provided to them via the LMS.

Type 4 activities – those that involve a student producing learning activities such as assessments – generally occur with more frequency on desktop devices than they do on mobile devices. Submitting an assignment through Canvas accounts for 3.5% of the activities performed on a desktop device but just 0.1% of the activities performed on a mobile device. However, this is not an absolute finding. Mobile users engage in both discussions and quizzes more frequently than other types of summative assessments. Participating in discussion topics accounts for 13.1% of the activities made by desktop users and 9.8% of the activities performed by mobile users. Quizzes account for 6.1% of desktop activities and 3.8% of mobile activities. It may that these types of assessments are more appealing to users on mobile devices because of their visual simplicity and/or their relatively shorter duration, which again supports the findings from the survey and focus groups.

Research Question 4: What do students believe are best practices for the design of learning activities on a mobile device?

Students who responded to the survey were asked to rate a series of statements related to their experience of performing academic work with their smart phones on a Likert scale where 1 represents "Strongly Disagree" and 5 represents "Strongly Agree." Almost three quarters of students reported that "(t)here are times when I *need* to use my smart phone for academic work": 35.6% of students strongly agreed with that statement, and an additional 36.2% of students somewhat agreed. However, nearly just as many students reported that they "don't like using (their) smart phone for academic work." This statement was strongly agreed on by 43.4% of students and 27.5% selected "somewhat agree." Over half (53.1%) strongly or somewhat agreed that having access to their course materials on their smart phone would help them succeed in achieving their degree, but less than 40% of students strongly or

somewhat agreed that they are able to perform the academic tasks they need to on their smart phones. Some of the disconnect may be due to a lack of understanding of how smart phones are used between instructors and students. Just 22.6% of students strongly or somewhat agreed that instructors understand how they (students) use their smart phone. This section will provide feedback related to the instruction and instructional design practices that students have enjoyed, have hated, and would like to see more of in the future.

Organization of Instructional Tasks and Learning Activities

The organization of content related to instructional tasks was frequently cited by students as being critical to their success – and the disorganization of content was the source of many frustrations. A focus group participant simply stated that:

> I wish instructors could leverage Canvas's functionalities more effectively, such as creating a more friendly course interface, clear layout and structure of the course. For instance, they could have created modules or overview pages for each week to share resources and key takeaways from each week, or a sort of 'To-Do' list.

Students seem to be in general agreement that many of their Canvas sites are not set up well to begin with. One focus group participant stated, "Maybe have better ways for (instructors) to learn Canvas like Canvas 101. I have so many professors where they just completely don't know how Canvas works at all." Organizing content within the LMS then allows students to take advantage of the tools they feel help them be successful, as summarized by a survey respondent:

> I use the To Do List for everything, it is the most important tool in Canvas. All professors should be required to list assignments so they show up on every students' To Do list. It really helps the students especially when they can trust that everything is properly listed for each class.

Other students reported difficulty in finding resources because instructors or designers had simply uploaded a large number of files into Canvas but had not used the organizational tools within the LMS to group related files together. A focus group participant provided insight to this situation:

> I have a professor right now who's got like a map of master links. And you click that it takes you to the file section in Canvas, and then it's all of his assignments. But they're like URL links. So, they're not even like titled, so you have to click on Find out which one's the one you actually need. And it's a really big inconvenience.

In a follow-up statement, the same participant said, “I don’t know what’s going on at all, let alone on my phone.” A survey participant noted that even organized materials are not necessarily optimized for the smart phone: “(I) love to use (my smart phone) but seeing attached or linked documents to an assignment sometimes requires using a bigger screen (ex: laptop).” This was supported by another student who noted that there were lots of resources available, but their use was limited due to their organization:

> A lot of professors have videos leftover from last year when everything was online. So, they're kind of like a supplementary study tools. And they're just not worth accessing on my phone, just due to how they're uploaded to Canvas as attachments – It's either that I can't find it. I can't open it. Or it'll take me to like a third-party browser or something. And I just don't know. It just makes it less easy to use.

Consistency of Canvas design was also mentioned by several students. Said one focus group participant:

> It's the way (instructors) have the page set up sometimes is just completely unrealistic, or just all over the place. It's there's not really like a systematic order to anything. I personally, like when they kind of like do modules by the week, and it just kind of scrolls down. Some people you have to, like, go into this to find this video under this file under that week. And it's just a lot more

> searching than just going and finding the information. It's just some people just seem to really have it the whole process, and then others are just kind of posting things to their page.

Another student agreed and shared her experience with two Canvas sites:

> I have one online course, and the professor is struggling – the way he has (Canvas) set up is so bad that we had to get the Dean involved. His quizzes and everything are always so disorganized. He doesn't know how to post things without making anything a broken link. But my other class is just so organized. That's so nice to use. And that is an in-person class. So…it's very different.

Further, graduate students noted that Canvas is not used nearly as much in their graduate courses as it was in their undergraduate experience. This was found to be a hinderance to performing academic work on smart phones because of the lack of centralized resources. Stated one survey respondent: "Many graduate professors don't integrate Canvas much into their courses. If the professors used it, then I would be using many more functionalities of the app on my phone."

Canvas Modules

Several students described how content segmentation and organization led to successful experiences in their courses, and many specifically mentioned the modules tool available in Canvas. Said one survey respondent:

> A lot of instructors I have currently organize all the class materials on Canvas into weekly modules, and I love it. It's a super easy way to keep everything organized & in one place, and I never have to guess where an assignment or reading will be.

A focus group participant lauded the organization of one of her courses:

> My organic chem professor has her Canvas set up so nicely – like every chapter is its own little module tab, you can click on it, and the links are organized with sections. It's like brief

> descriptions. It's nice because she also has a different tab for the recordings that are organized and with the chapter where they belong. And she has the homework and everything included.

Another participant noted that the structure of Canvas modules aligned with the structure of the course itself was very helpful:

> Modules are great. And I like having it broken into blocks as well. So, we might know that block one is for the first test, block two is the second test, and block three is the third test. Then we'll have an overarching final at the end, so having that sectioned out and then having all the recordings sorted into the blocks as well, so that you're not scrolling through this huge list to try and find the recording that's associated with that specific section.

Consolidation of Content Delivery Platforms

Beyond Canvas, students noted that they were expected to perform academic work in a wide variety of different software – sometimes even within the same course. E-text platforms were frequently cited as an example where this is the case. This was evident in one focus group participant who described her experience in an introductory Anthropology course that had two e-texts in two separate platforms. Another student notes that professors are sometimes unfamiliar with the platforms as well:

> Our courses are still not designed for e-texts. The information is there but many of our professors don't understand how the digital book formats work and when we have issues, our professors aren't always supportive or understanding of how a book can malfunction.

Another student noted that their experience with Canvas "…generally works well, but sometimes the screen doesn't allow me to see everything that is there, especially when Pearson homework assignments are embedded into the Modules section of Canvas." A focus group participant followed up on the comment about Pearson resources:

> It doesn't go through the platform as my other e-texts. It would be preferable if it was just a PDF but publishers probably don't allow that. But if there was some standardization in the web browser, we wouldn't have such an inconsistent experience.

And although students generally dismissed the idea of reading their e-texts on their smart phones (as discussed in Research Question 1 on page 44), several students referred to the convenience of referencing their textbooks on their smart phone while working in small groups or while in the classroom. One student noted, however, that there were "too many different apps" to keep track of.

Availability of Recordings and Audio/Video Assets

Students in general were very much in favor of having access to recordings of classes. A survey respondent noted that "My courses are all online, and recordings are made available by instructors along with copies of slides. This is very helpful and far superior to anything I could attempt with my phone or tablet." Some students had good experiences with the recordings and their ability to work on their smart phone: "Canvas has done a fine job of making academic recorded videos compatible with smartphones." Another survey respondent stated:

> It would be much easier if I could access recordings of every class I take because, while I take notes, none of those notes are with sound and sometimes my teachers handwriting is hard to read, or they move a bit too quickly through notes. So being able to go back and check if I wrote something down correctly and if I understood would be very nice.

When recordings are not made available by the instructors, students appear reluctant to create their own. A survey respondent notes that "A lot of professors don't want you to take pictures with them in it and I've had professors that prohibit recording any audio in the classroom or recording video from personal devices." This sentiment was echoed by other students as well: "A lot of law school and undergrad professors prohibit videos or audio recordings during classes," and:

> I would love to use my smartphone to record lectures or take notes. However, in a lot of classes, professors have negative views towards technology. I've had many courses where the professor will not allow students to take notes on their laptops/phones.

The Use of Audio Content

As discussed previously in Research Question 1, students appear to be very interested in audio-based resources for their instructional tasks. This is summarized by one survey respondent who said, "AUDIOBOOKS *[sic]* would be the most beneficial, and I'm a grad student in my 30s. I have grown accustomed to driving and exercising while listening to books and I can't understand we don't have that option yet for textbooks. I am a mom and a full-time nurse as well as a grad student, I don't have 10 hours a week to sit and read." Students also referred to the benefits of listening (but not necessarily watching) recordings of class sessions:

> I had a class where they recorded it both on Kaltura and then also zoom externally. And that allows you to like download the video offline so that you don't have to stream it, which was super helpful. And then also lets you play in the background without having to have the app open and like the video running. So like, if I'm just going to listen to the audio, and I'm not going to watch the slides.

One student noted simply: "Let me download recordings for offline use and let them play in the background."

Delivery of Handouts and Classroom Artifacts

Students were asked to rate their top three preferred note-taking practices in both in-person and online (or recorded) courses. For both course modalities, taking notes with pen and paper was the most frequently stated preference. For in-person courses, the second most highly rated note taking technique was to markup printed handouts provided by the instructor. This was the first choice (24.1%), second choice (27.3%), or third choice (15.6%) for 67.1% of students. However, only 47.1% of students

in online or recorded courses rated the use of printed handouts as one of their top three notetaking preferences. Students in those courses chose to take notes on a laptop more frequently than marking up handouts. This could indicate that students in online or recorded courses are unable or unwilling to print physical copies of the documents if they are not provided by the instructor, or that students in in-person courses have easier access to print documents. Just 18.3% of students chose the option to annotate handouts on a tablet in an in-person class and 19.2% of students said the same for online or recorded lectures. Annotating handouts on a smart phone was the least preferred notetaking options for both course modalities.

However, students who took advantage of the distribution of slides and handouts were in favor of the practice. As noted by one survey respondent:

> I wish more instructors would provide notes or outlines for their lectures. Having a structure to go off of or a set of blanks to fill in makes it easier to stay engaged in class, and makes it easier to study, knowing exactly what the instructor thinks is important.

Students also stated that having access to the documents prior to class was helpful. A focus group participant noted that she takes "…the pre notes for most classes because my professors sometimes go through the slides too fast in class – and so I already have an idea what is going to be discussed." Another participant stated their use for PowerPoint files during class:

> I really like (having the files) – essentially if you just printed out the PowerPoint slides and followed along and took notes on them. I just like to have the structure and then I can add more to them as the professor's talking, instead of just getting the PowerPoints after.

Using Smart Phones to Record Instruction

One common use for smart phones reported by students was the ability to supplement their notes by taking photos. A survey participant states, "If I can't copy notes fast enough I will take pictures of the chalk board or white board if I know that material will not be posted on Canvas." Other students

noted that not having access to the documents themselves influences their choice to take photos of instructional materials: “I will only take pictures when in a hurry or the PowerPoint/said materials are not available on our canvas course website,” and “Sometimes I have to take pictures, especially when something is being drawn on the board but won’t be uploaded to Canvas in any way.”

Consideration of Document Formats

A common challenge to students using their smart phones is due to the format of the content provided to them by the instructor or instructional designer. In particular, documents that are graphical representations of text were challenges for students. One survey respondent noted, “For some courses in the online Social Work program, I think the text loads as an image, so I can access it on my computer but not on my phone. That makes it impossible to use for studying.” Another noted that scanned documents are difficult to read: “I hate (those documents), especially the ones that are photo-copied images from textbooks.” Another succinctly described many students’ frustration: “Too many badly copied PDFs!”

Classroom Policies

Students noted a wide disparity in the classroom policies of different instructors. 57.2% of survey respondents report that they have had at least one course at Hudson University where the instructor has banned the use of smart phones in the classroom, and 32.9% report that they have had at least one course where laptop computers were banned. Students seem resigned to this fact, regardless of individual instructor policies, even when they themselves see the benefit. A survey respondent noted “electronics are highly discouraged in classrooms, so I don’t (use my smart phone).” Another discusses using a mobile device for notetaking: “I feel like certain professors might disapprove of this sort of usage, when it may be the best option for certain students (if they have trouble writing or some other handicap).” Another specifically noted the perception it could give to the instructor: “Honestly, it looks like I'm not paying attention in my classes if I use my smart phone.”

Students have sometimes been impeded by rules guiding access to devices in the classroom. One focus group participant described a situation where the instructor's course design was incongruous with her classroom policy:

> I have a class that's basically all (Canvas) module based with an e-text. So, we do all of our work online. And then we meet once a week, and when we meet, we can't have our computers out at all, even though all of our work is done online. So, then we just sit there and (the instructor is) like, 'Why don't you remember what it was over?' And I'm like, 'Well…my notes are on my computer.' It's just annoying because all of my work is on my computer, and I'm not allowed to have it out at all? Okay….

Another student in the focus group noted that this type of policy can even occur in computer-focused courses:

> And then you have professors who are like, "I don't want any technology in the classroom." And there is really nothing you can do. You might have technological courses like computer programming, or, you know, computer science courses and they're like, "No, you can't have your technology open." And I say to them, "But I take notes on my tablet – it's literally all I do. You can look come down and look at it. I'm not browsing." But, yeah, I have professors who sit there and go, "You can't have technology in the classroom. I don't want to see your phones. I don't want to see your computers. I don't want to see anything."

Some students in the focus groups discussed that it seemed that the number of "anti-technology" professors is decreasing but were still prevalent in their experience.

Chapter 5: Discussion and Summary

General Findings

Prior to the examination of results specific to each research question, I find it prudent to identify some common themes that emerged during the data collection process. These factors may provide the context needed to understand some of the findings specific to the research questions.

Hardware Use and Availability

Students at Hudson University appear to have sufficient computing resources necessary to complete their academic work. In fact, 92.5% of students report owning a laptop computer and 30.9% report having either a desktop computer or a Chromebook. Only 1.5% of students report that a smart phone is their only computing device. However, students in the focus groups noted that mere access to these devices may not be sufficient. First, as was discussed previously, students note that they are dependent on multiple digital resources at any given time (for example, an e-text or an instructional video) and frequently find themselves switching between resources while completing their work. This was a source of frustration to some, as they were unable to accommodate their immediate needs with the devices they had at hand. As noted, 76.5% of students who own a laptop do not have an external monitor. Thus, they are reliant on their smart phone as a supplemental screen or are relegated to splitting their screen or continually moving between windows – neither of which appeared to provide an optimal experience.

Another issue was the quality of the devices. Some students referenced that even though they owned a laptop or tablet computer the device itself was not powerful or reliable enough for their academic work. Some students noted that they used computing resources from their employment for academic work – either because their personal computer was not working or because the work computer had either a bigger monitor or multiple monitors. Finally, one student relayed a story of a time when his laptop (his only computer) was broken and left him without access to a primary

computing device for nearly a week while it was being repaired. As this was during the semesters impacted by the COVID-19 pandemic, he did not have campus resources available to him and he expressed surprise that there was no institutional support for someone in a position such as his.

The "Personal" Aspect of Personal Devices

Another interesting consideration emerged in both the survey respondents and focus group participants related to the ownership of mobile devices. Many students expressed a delineation between their devices in that they felt that their smart phone was their personal device used for their pleasure and at their discretion and their laptop or other computer was where their work should occur. Some students noted that this intersection of personal and academics can be a distraction when trying to perform academic work on their mobile devices. One graduate student who responded to the survey stated: "I try and separate school life and personal life" and another agreed: "I'm a part-time graduate student taking only online courses and working full time. I don't use my phone for school to help segment out my life." Another survey respondent noted:

> I chose to purchase items including monitors and a desktop computer so that I would not have to work on my phone really at all. I prefer to use my smart phone for socializing, watching videos/streams reading books for pleasure, scheduling and leaving reminders for myself, and listening to music/podcasts.

Another student noted a firm divide between their personal and academic spaces:

> I chose to purchase items including monitors and a desktop computer so that I would not have to work on my phone really at all. I prefer to use my smart phone for socializing, watching videos/streams reading books for pleasure, scheduling and leaving reminders for myself, and listening to music/podcasts.

One survey respondent summed up the feeling succinctly: "My phone is more a personal thing. Using it for academic work feels weird."

Research Question 1: What types of academic work do students want to perform on their mobile devices at a large public university?

Students report both widespread and frequent use of their smart phones for academic work. Over half of students (54.3%) reported that they use their smart phone once per day or more for academic work, and an additional 23.8% that noted they used the device several times per week. In the Fall 2019 semester, 93.5% of students used a mobile device to access the Canvas LMS at least once, with 88.9% using their mobile device to access Canvas more than five times. The specific activities that students perform on their mobile devices generally fall into two categories, as described in the section Technology-Enabled Academic Activities in a Community of Inquiry on page 15: communication and interaction and instructional tasks.

The Smart Phone as a Conduit to Academic Work

Communication and interaction were the most popular uses for a mobile device, with students most often using the devices to review grades, course announcements, and due dates. This finding, when compared to the responses provided by students in open-ended questions and the focus group, demonstrate that the students tend to use their mobile devices for shorter duration activities. Therefore, we may consider that for many students, the smart phone is a trigger that leads the student to pursue more in-depth work on a different device (presumably a laptop or desktop computer).

"I'd Like to Do This" and Instructional Tasks

Students also report using their mobile devices for instructional tasks – those Type 2 activities that are highly individualized and have high transactional distance. Specific academic work in which students perform on their devices includes listening to audio resources or podcasts, watching assigned videos, and reading Canvas videos. Of interest, though, is the fact that three Type 2 activities were most cited as activities that students would "like to do" with their devices; specifically, 23.1% of students would like to listen to audio resources, 16.2% of students would like to watch assigned videos, and

14.1% of students would like to read or reference their textbook. Given that these three activities are technologically possible with the platforms and devices in use, there is some disruption in the students' perception that they can. A few of these potential perceived barriers are discussed below, but there also appears to be a knowledge gap amongst some of the students.

Learning Activities on Mobile Devices

In general, students were least likely to perform learning activities using their mobile devices. These activities include Park's Type 4 activities such as assessments, papers, and exams. They appeared, however, more likely to perform less-complex activities such as discussions and quizzes using mobile devices. This corresponds with the findings by Chung, et al. (2019) that demonstrate students were most likely to perform instructional tasks and simpler learning activities on mobile devices. However, demographic differences emerged that demonstrate the students should not be treated as a single entity. Undergraduate students are more likely than graduate students to perform academic work on their mobile devices. This difference may be due to the fact that the actual work done by undergraduates is less complex – and, therefore, easier to accomplish on a device. Or, this finding could simply be reflected by the trend toward mobile device use by younger students, as seen in Figure 7 Percentage of Canvas sessions by device type and age group on page 73. Full-time students were also more likely to use their mobile devices for learning activities than part-time students. Again, this difference could be due to the influence of age, or it could be that full-time students have a better understanding of how to perform these tasks on their mobile device.

Of perhaps the greatest importance is the finding that students who are eligible for Pell grants are more likely to perform learning activities using a mobile device than students who are not Pell-eligible. This result means that students who have the greatest financial need are also likely more dependent on their mobile devices to complete academic work and could indicate that they have fewer (or less reliable) computing resources available to them.

Distinction Between Phones and Tablets

Although this study did not attempt to make a distinction between smart phones and tablets, the results show that students treat those devices quite differently. Smart phones are regarded almost as necessities – they are owned by 98.3% of students – whereas tablets are owned by just one third (35.1%) of students. This disparity in ownership was discussed in the focus groups, with many participants agreeing that the purchase of a tablet was less important than the purchase of a smart phone and a laptop. Other students noted that they had not ever tried a tablet and, thus, could not gauge its potential benefits. As stated by one student: "I'm not really willing to drop the money on one just yet – just to see if I like it." Still, students that owned tablets and used them for academic work highly praised their capabilities. Said one student:

> I love taking notes with a tablet. I use the MS Surface Pro 7. I submit assignments from it too. I don't have to print my paper assignments. I just directly write on the PDF and turn that in. Good for the environment!

The additional screen size afforded by tablets is more appealing for both reading as well as watching instructional video. And notetaking appears to be significantly more appealing to students using tablets than students using smart phones.

The Impact of Multiple Screens on Device Choice

Students repeatedly emphasized the number of digital resources that they use simultaneously while performing academic work and noted their need to reference multiple windows, tabs, or screens while studying. As succinctly stated by one student: "having two monitors is such a game changer." This appears to be yet another factor in the decision regarding which device to use when engaging in academic activities. Said one student: "I use my laptop or desktop computer. Because of my additional monitors on both, it is much easier to complete assignments on those platforms." Students who have

limited monitors or screen space note that this is a hinderance to their ability to work with multiple resources, and that the computer labs provided by the university just replicate what they already have:

> The computers we have at school are pretty much like not useful, because anything I can do on there, I can do my own computer. But it'd be really helpful if they just made dual monitors, or like just let us connect our computers to some of the monitors (because no one uses them anyway) – it'd be so cool to have two monitors.

Research Question 2: What barriers do students encounter when using their mobile devices for formal learning at a large public university?

Numerous barriers to using mobile devices for academic work were identified by the students. The barriers can be classified into three categories:

- Technological barriers – those that relate to the usability of the hardware or software itself
- Institutional barriers – a disconnect between the services provided by the university and those sought by the students
- Instructional barriers – difficulties in accessing learning materials or participating in academic work due to flaws in the instructional design or implementation

Technological Barriers

The most commonly cited barrier to using a mobile device for academic work is the physical dimensions of the device itself – specifically, the smaller screen size when reading and viewing and the general discomfort or perceived inferiority of using the onscreen keyboard for input. These are not issues that can be easily addressed through instructional design and will likely remain prevalent as long as educators continue their existing pedagogical processes.

However, this study did reveal that there are some knowledge gaps in the capabilities of the mobile devices and the perception of those capabilities by students. All the 29 specific academic

activities noted in the survey are technologically possible (but perhaps not preferable) with the smart phones and tablets on the market today. Students reported that they either do or would like to do five of the six instructional tasks that were presented in the survey more than they don't want to do those tasks. The reasons that they "would like to" but believe they *cannot* do these activities is unknown but is likely due to an inability to find or use the resources that are delivered combined with an unawareness in how to properly utilize them. And, as noted, there are some demographic differences between student groups and the use of their devices. Full-time students use their mobile devices for academic activities more frequently than do part-time students, but part-time students were more likely to disclose that they "would like to do" some of those activities. It is possible that full-time students are simply more aware of the capabilities of the devices. Whether that is due to age, exposure to informal learning from peers, experience gleaned in the classroom, or some other factor is not known.

Institutional Barriers

Students reported barriers due to conditions that are purely under the purview of the institution – particularly when it came to the choice of platforms used to deliver instructional content. Functionality differences between these platforms and their most common consumer counterparts were cited frequently, such as the missing features in Kaltura, the video delivery platform selected by Hudson University, and YouTube. Over 83% of students report watching non-academic video on their smart phones, yet only 36.3% use their phones to watch academic video. Although the functionality difference between YouTube and other consumer video apps may not be exclusively responsible for this distinction, the popularity of consuming video on smart phones likely builds habits and expectations for all videos played on this device. Thus, the platform used for academic video should not contradict those habits and expectations. This disparity between consumer and academic software was also noted for e-texts. As noted by one student: "I like using e-texts for school, but sometimes certain texts do not allow me to save what I have highlighted or added a note for." Another noted:

> I prefer it only if I can use it in an advanced reader so I can highlight and comment. Some of my classes have e-texts but are hard to access and you can't use them in an advanced reader making it so hard to study with.

Students also reported that they were unable to use the instructional materials in the way that they chose, which is a concern that Universal Design (Salmen, 2011) and the Universal Design for Learning framework (CAST, 2018) attempt to address. Many students reported either a dislike of the e-text experience or a lack of understanding of its features – or both. Although e-texts seemed popular with many students – particularly for convenience and the ability to search – many felt that they should be able to choose the format for their textbooks rather than have that decision made for them. Said one student:

> I only have one e-text for algebra, and I don't like it. It takes a minute to get it pulled up on my laptop and the size of the e-text isn't right. I would've purchased a physical book for algebra, but I was told that I had already been charged (and paid) for the e-text so I didn't want to spend any more money than I had to.

And some students who like e-texts overall simply wanted the ability to use the material in the application of their choice. Said one student:

> I really do not like the DRM that major publishers use to prevent PDF sharing of books. PDFs are the fastest, easiest, most portable, and most searchable documents for academic books. I can learn faster when not obstructed by having to use proprietary software to access a book.

The notion of choice was a frequent refrain in discussions with the students, which aligns with the findings by Schunk and Pajares (2002) that a student's autonomy is important in the development of self-efficacy in their academic activities. Other barriers that the students perceived were the inability to download instructional videos (thus allowing them to play the videos in the software of their choice) and the lack of option to choose audio versions of instructional materials.

Finally, students felt that there was little support for physical technology from the institution, apart from the computer labs available for students who are on campus. The institution does not provide any opportunities for students to borrow equipment – as in the case of the student with the laptop in for repair – or test new technologies, such as tablets. There are also few options for students to use their personal devices with additional monitors when they desire to do so while on campus.

Instructional Barriers

Students identified several instructional barriers to using their mobile devices for academic work. The most prevalent of these barriers was simply an inability to easily locate the instructional content they sought on a regular basis, which represents a loss of control on the part of the learner and can negatively impact their experience (Taylor et al., 2006). The disparity in organization of Canvas sites was cited frequently, and students explained that it was easier to both search as well as explore ill-organized resources on a laptop or desktop computer. Students also noted that many instructional materials were not suitable for use on mobile devices – such as poorly-scanned documents, fixed-layout PDF files, and images that contain text. This type of barrier not only negates the ability for students to use the device of their choice but presents accessibility concerns for students with disabilities and violates the principles of Universal Design for Learning as well (Tobin, 2018). Finally, students recognize that more instructors are allowing the use of personal technology in the classroom but still face disparate and confusing classroom policies and some resistance on the part of instructors.

Research Question 3: How does a student's learning behavior differ based on the device in use at a large public university?

The purpose of this research question was to analyze actual student behavior when interacting with learning technologies on both their desktop/laptop computers as well as their mobile devices. To examine their behavior, I reviewed the automated logs generated by students in their interactions with the Canvas LMS for the Fall 2019 semester. These interactions were grouped into sessions that

represent a student's repeated activities within one specific Canvas course site within a span of time. In that semester 89,534 students used the Canvas instance at Hudson University at least one time, providing a rich set of data to examine and elicit trends.

Most students had a longer average session time when using Canvas on their computer as compared to their mobile device. Only 5.3% of students had an average session duration that was longer when using a mobile device as compared to a computer. Students on computers had an average Canvas session length of 6.95 minutes, while the average session length for students on mobile devices was 2.94 minutes. This is consistent with previous findings in this study that show that students prefer to use their mobile device to interact with Canvas when performing less-complex activities over shorter durations, such as reviewing an assignment or a grade.

A few differences emerged when reviewing the demographics of the students. Students at the regional campuses of Hudson University were found to access Canvas from a mobile device more frequently than their peers at the core and urban campuses, and the average length of those mobile sessions was also higher for students on the regional campuses. The number of sessions that occur on mobile devices also decreased with age; that is, students in younger age groups accessed Canvas on a mobile device more frequently than students in older groups. Finally, students who are enrolled on a full-time basis used Canvas on their mobile devices more frequently than part-time students. It was also found that late night (midnight to 4am) and early morning (4am to 8am) were the times when it was most common for students to access Canvas using their mobile device.

The entry points for Canvas sessions differed between students using a computer and a mobile device. Students on computers most frequently begin their sessions on an individual assignment page – likely accessed from the Canvas To Do list or Calendar tool. The second most common entry point for computer users was viewing an attachment. Mobile users, on the other hand, seem to take a more circuitous route to access content with Canvas. Over one quarter of sessions that take place on a mobile

device, 26.4%, start at the course home page. This could indicate that students using the mobile devices are unaware of the ability to navigate to the to do list or calendar within the mobile application.

The activities performed by students also differ by the device used to access Canvas. The most common activities on both device types are instructional tasks that are aligned with Park's Type 2 activities. Students on mobile devices most frequently access the details of a specific assignment (19.7% of all Canvas activities on a mobile device), view the course home page (18.5%), and view the course assignments list (14.6%). Students on computers most frequently access attachments (23.5% of all Canvas activity on a desktop or laptop device), view an assignment's details (11.7%), and view discussion topics (9.8%).

Students performed learning activities aligned with Park's Type 4 activities much less frequently on mobile device than on computers, but students do perform some assessments on those mobile devices. The learning activities that are most frequently conducted on a mobile device are participation in discussions and quizzes, which are those that are the least complex and shortest in duration – corresponding with the overall preferences of mobile device users.

Research Question 4: What do students believe are best practices for the design of learning activities on a mobile device?

Although students were not directly asked to provide examples of positive instructional designs they have encountered, their preferences (and frustrations) were stated frequently in both survey responses as well as focus groups. The most frequently noted positive design factor was simply the organization of the course content into meaningful representation for the users. Students were frustrated that their Canvas sites were organized so differently from one another and the disparity in understanding even the most basic Canvas features amongst their faculty and instructional designers. While this design feedback was not specific to the use of Canvas on mobile devices, students noted that it was easier to overcome these barriers when using a computer rather than a mobile device. Students

describe instances of searching through multiple files for content, which was easier to do with a larger screen and without accidentally opening a document in a different mobile application. Students noted that the Modules structure within Canvas sites was beneficial, so that they could easily see the structure of a course. They also reiterated their dependence on the To Do List and Calendar tools built into Canvas – noting that they have missed assessments and other deadlines because those items were not included in the overview those tools provide.

Those students who were able to access the content for their courses made use of those documents. Annotating printed handouts was the second most popular notetaking method for students in in-person courses. This technique was also popular with the students that use tablets for notetaking in their courses. Students expressed much support for increased access to such handouts, including PowerPoint slides, so that they could annotate while attending class or reviewing video recordings. Respondents did, however, relate instances where the documents were not usable on mobile devices due to their fixed layout, small font size, or because they were images of text rather than actual text content.

Students also expressed a desire for fewer different platforms used to deliver learning content. They detailed instances where their texts were in multiple software applications and that the content they needed was not available in the software of their choice. This supports the frustrations mentioned in Research Question 2, where students with limited screens were expected to partake of multiple digital resources at the same time but found themselves unable to arrange the content in a way that met their expectation.

The availability of audio and video resources was a popular topic for students and corresponds with the Universal Design for Learning framework's emphasis on providing multiple means of representation (CAST, 2018). Students emphasized that they appreciated access to recordings of classroom sessions for review and to supplement their understanding but noted some frustrations with

the platforms used to deliver those videos as the functionality did not match their expectations built from using other video sources. A relatively surprising finding was the emphasis students placed on the value of audio-based content for instruction. Several students noted that they listened to classroom recordings while performing other learning activities and others opined the lack of audio options for textbooks and other text-based content. Multiple comparisons were made to podcasts and audiobooks, and students seemed curious why their content was not available in these popular formats.

Finally, students also expressed frustration when they were not allowed to use their devices during classes because of instructor policies. This is no longer merely a preference for students but rapidly becoming a necessity as their texts and ancillary resources are increasingly delivered electronically. Students who are unable to access their course resources during class time indicate that this has a negative impact on their ability to participate and succeed in the course.

Limitations of this Study

Although this study is broad in scope, there are a number of limitations that must be considered. First, the choice was made to examine the Canvas logs for the Fall 2019 semester in order to review a semester uncomplicated by the COVID-19 pandemic, but the student surveys and focus groups were conducted in the Fall 2021 semester and likely reflect the student experience after 18 months of living and working through the pandemic. Therefore, there may be some disparity between the students' reported preferences and experiences and their actual behavior in the Canvas LMS.

Examination of the actual student behavior was limited to those interactions within Canvas simply because it is the single most unifying learning technology in use at Hudson University. Although the University has a comprehensive e-text initiative (Abaci et al., 2020), not all textbooks are delivered through that platform. And though the university prescribes Kaltura as the platform through which instructional video should be delivered, anecdotal evidence shows that instructors use the platform with which they are most familiar – including YouTube and Vimeo. Even if it were possible to obtain all the

usage logs from all these disparate platforms, it would be quite difficult to examine them as a whole. The varied user experiences, functionality, and organization do not lend themselves to comprehensive study. Therefore, the choice was made to limit the study's examination of actual student behavior to the Canvas LMS, which acts a hub for multiple educational technologies and is the tool most often used by students.

Finally, the Canvas data that was made available for this study *only* includes the records of student interactions within specific Canvas course sites. This limits the ability to examine student behavior in the centralized (not course-specific) tools in the Canvas software, such as the Inbox, To Do List, and Calendar. Without access to this data, it is difficult to build a comprehensive overview of student activity in Canvas beyond the patterns I have already been able to discern.

Opportunities for Future Research

This study barely scratches the surface of investigating how students use their mobile devices for academic work. First and foremost, this study focused solely on student's *formal* learning activities, which leaves out all the important scholarship and inquiry that studies how students use their devices for communication with their instructors and peers. This is an area of study that is well underway but is constantly in flux as students discover new technologies such as Discord and Slack – and while their academic environment remains in flux due to the pandemic.

Another avenue for study would be to conduct usability analysis of students' behavior in the Canvas LMS on both a computer as well as a mobile device to either confirm or provide more insight into the findings noted here. The log data itself is a rich and bias-free record of student behavior but does not include any information about *why* a student may have behaved in a certain fashion. A related user experience study would provide more well-rounded understanding about the students' choices and barriers when working with Canvas.

The physical computing setup – specifically, the number of screens – used by students while performing academic work was not a primary focus of this study but many of the responses provided by students indicate that this would be an area ripe for investigation. Students' dependence on digital resources in higher education cannot be understated, yet the University (and the higher education system in general) tend to leave it up to the students to provide the technology able to properly utilize those resources. This appears to be a disconnect, and students who may superficially appear to have "everything they need" may, in fact, be under-resourced. Does the presence of additional monitors afford an educational advantage to those that have them? Would students use tablets for reading and notetaking more if they were familiar with the technology? A comprehensive study into the physical hardware used by students seems necessary, if for no other reason than for universities to understand the resources students have available while selecting the learning technologies to implement.

Finally, a more thorough analysis of the Canvas log data should be performed to detect other patterns that are not immediately apparent from my relatively superficial view of student behavior. By combining more rich demographic information with the behaviors recorded in Canvas we could learn a great deal more about the external influences that lead students to use Canvas in a particular fashion. This is simply a massive amount of data but is perfect for the application of machine learning algorithms and deep data mining to more fully paint the picture of the students who are engaging with the software.

Conclusion

This study discovered that students do use their mobile devices for significant amounts of academic work but are selective about the specific activities they undertake on those devices. Their decision about which device to use is based on a number of factors, both internal and external. Students tend to use their mobile devices for activities that are most convenient to them – checking in on a course or reviewing brief communication – but have also identified several factors that prevent them (or

have dissuaded them) from using the mobile devices for other activities. The students acknowledge, somewhat reluctantly, that mobile devices are an important part of their academic computing ecosystem – 71.8% of students report that they need to use their smart phone for academic work, but 70.9% of students don't like doing so. Beyond their stated preferences, there are some external barriers that prevent them from using their devices more proficiently. Only 39.7% of students agree that they are able to perform the academic tasks that they need to on that device.

As noted earlier, Kukulska-Hulme and Traxler (2019, p. 1) state that

> Education is no longer designed for a group of learners situated in a defined context; rather teachers face the challenge of designing for individuals who engage in their own learning, through their own devices, from their own settings, and on their own terms.

The notion of student choice reverberated throughout every focus group and many comments provided by students in the survey. Students feel hemmed in – responsible to provide the technology needed to conduct their academic work but sometimes unable to use that technology in the form or fashion that they feel is best. This was true whether the students were discussing their use of mobile devices or their computing resources in general. The decision of whether to use their mobile device for academic work is based on a combination of both internal experiences and preferences, balanced with the realities, capabilities, and limitations of the external digital resources they are expected to utilize.

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Appendix A – Survey Instrument for Anonymous Student Survey (Group 1)

Q0 I acknowledge that I would like to take part in this survey and that I am at least 18 years old.

- Yes (1)
- No (2)

Q1 Please check all the devices that you own or regularly use:

- A "basic" mobile phone (a phone which CANNOT install apps) (1)
- A "smart" mobile phone (a phone which CAN install apps) (2)
- An e-reader (an electronic reading device that CANNOT install apps) (3)
- A tablet (a portable electronic tablet that CAN install apps, including iPad) (4)
- A laptop computer (including Microsoft Surface) (5)
- Chromebook (6)
- A desktop computer (7)

Q2 Do you have an unlimited data plan for your mobile phone?

- Yes (1)
- No (2)
- I don’t know (3)

Q3 What is the operating system for your smart phone?

- Apple iOS (1)
- Google Android (2)
- Other (3)
- I don’t know (4)

Q4 What is the operating system for your tablet?

- Apple iOS/iPadOS (1)
- Google Android (i.e., Samsung tablets) (2)

- Amazon Kindle Android (i.e., Kindle Fire tablets) (3)
- Other (4)
- I don't know (5)

Q5 Do you have an external monitor that you use with your laptop or Chromebook?

- Yes, 1 external monitor (1)
- Yes, 2 external monitors (2)
- No (3)

Q6 How many monitors does your desktop computer have?

- 1 monitor (1)
- 2 monitors (2)
- 3+ monitors (3)

Q7 Which of the following apps do you have installed **on your smart phone**? (Select all that apply)

- IU Mobile (1)
- Canvas Student app (known as "Student") (2)
- TopHat (3)
- Boost (4)
- Unizin Read (5)
- Quizlet (6)
- VoiceThread (7)
- Microsoft Office (23)
- Microsoft OneDrive (20)

- Microsoft Word (8)
- Microsoft PowerPoint (9)
- Microsoft Excel (10)
- Microsoft OneNote (24)
- Microsoft Teams (11)
- Google Drive (12)
- Google Docs (13)
- Google Slides (14)
- Google Sheets (15)
- Discord (16)
- GroupMe (17)
- Zoom (18)

Q8 Which of the following the apps are you aware of but **do not** use **on your smart phone**? (Select all that apply.)

- IU Mobile (1)
- Canvas Student app (known as “Student”) (2)
- TopHat (3)
- Boost (4)
- Unizin Read (5)
- Quizlet (6)
- VoiceThread (7)
- Microsoft Office (8)
- Microsoft OneDrive (9)

- Microsoft Word (10)
- Microsoft PowerPoint (11)
- Microsoft Excel (12)
- Microsoft OneNote (13)
- Microsoft Teams (14)
- Google Drive (15)
- Google Docs (16)
- Google Slides (17)
- Google Sheets (18)
- Discord (19)
- GroupMe (20)
- Zoom (21)

Q9 If you have installed other smart phone or tablet apps that you use for academic work, please list them here:

Q10 How often do you use each of the following devices for learning activities (reading, studying, completing assignments, etc.) – (Options: Once per day or more, Several times per week, About once per week, About once per month, Never)

- A "basic" mobile phone (a phone which CANNOT install apps) (x1)
- A "smart" mobile phone (a phone which CAN install apps) (x2)
- An e-reader (an electronic reading device that CANNOT install apps) (x3)
- A tablet (a portable electronic tablet that CAN install apps, including iPad) (x4)
- A laptop computer (including Microsoft Surface) (x5)

- Chromebook (x6)
- A desktop computer (x7)

Q11 Please describe if you would like to perform each of the following Canvas activities **with your smart phone**. (Options: I do this, I'd like to do this, I didn't know I could do this, I won't do this)

- View course announcements (2)
- View your Canvas calendar (3)
- View your Canvas To-Do list (4)
- View the course roster (5)
- See push notifications from my courses (6)
- Review the requirements for an assignment (7)
- Review the due date of an assignment or exam (8)
- Review your grade for an assignment or exam (9)

Q12 Do you have anything to share about using Canvas with your smart phone?

Q13 Please describe if you would like to perform each of the following reading and media activities **with your smart phone**. (Options: I do this, I'd like to do this, I didn't know I could do this, I won't do this)

- Read or reference an assigned textbook (2)
- Read or reference class notes or handouts (3)
- Read Canvas pages provided by the instructor (4)
- Watch a classroom recording (5)
- Watch an assigned video on a specific topic (6)
- Listen to an assigned podcast or audio recording (7)

Q14 Do you have any comments about reading or watching media for school on your smart phone?

Q15p Please describe if you would like to perform each of the following note taking activities **with your smart phone**. (Options: I do this, I'd like to do this, I didn't know I could do this, I won't do this)

- Take notes during class or while reviewing course materials (2)
- Take photos of course materials (3)
- Take photos of whiteboards or classroom activities (4)
- Take video of whiteboards, lectures, or classroom activities (5)
- Make an audio recording of a lecture or classroom activity (7)

Q15t Please describe if you would like to perform each of the following note taking activities **with your tablet**. (Options: I do this, I'd like to do this, I didn't know I could do this, I won't do this)

- Take notes during class or while reviewing course materials (2)
- Take photos of course materials (3)
- Take photos of whiteboards or classroom activities (4)
- Take video of whiteboards, lectures, or classroom activities (5)
- Make an audio recording of a lecture or classroom activity (7)

Q16 Please share any thoughts you have about using your smart phone or tablet to take notes for your courses.

Q17 Please describe if you **use your smart phone** to communicate about your courses**.** (Options: I do this, I'd like to do this, I didn't know I could do this, I won't do this)

- Send or respond to a Canvas Inbox message with an instructor (2)
- Send or respond to an IU email/Gmail message with an instructor (3)
- Send or respond to a direct message with an instructor (4)
- Send or respond to a text message with an instructor (5)
- Send or respond to an informal message from classmates (7)

Q18 Please share any comments you have about using your smart phone to communicate with your instructor and classmates.

Q19 Please describe if you **use your smart phone** to perform assessments for your courses**.** (Options: I do this, I'd like to do this, I didn't know I could do this, I won't do this)

- Record a short introductory video for a course (2)
- Participate in a graded discussion exercise (3)
- Take a short quiz (4)
- Write a short essay (5)
- Take an exam (7)
- Write an academic paper (11)

Q20 Do you have anything to share about using your smart phone to complete assignments for school?

Q21 Is there anything else you would like us to know about using your smart phone for academic work?

Q22 Which, if any, of the following conditions have prevented you from using your smart phone for academic work? (Select all that apply.)

- Small screen size (1)
- Fixed font size (4)
- Technology did not function (5)
- Technology/app was not available (6)
- Too much information on one screen (7)
- Could not rotate screen to preferred layout (8)
- Could not access the content or application (9)
- Display on smart phone was inaccurate or unusable (10)
- Less functionality than the desktop/laptop version (11)
- Bad WiFi or connectivity (12)
- Other (please specify) (13)

Q23 What, if any, are some other reasons why you have not been able to use your smart phone for academic work?

Q24 Please rank your top 3 preferred note-taking practices during an **in-person** lecture or course. Please enter **1** for your first choice, **2** for your second choice, and **3** for your third choice.

- _____ Pen and blank paper (1)
- _____ Pen and printed handouts provided by the instructor (8)
- _____ Typing on a laptop (9)
- _____ Annotating documents or textbook provided by the instructor on a laptop (10)
- _____ Annotating documents or textbook provided by the instructor on a tablet (11)
- _____ Annotating documents or textbook provided by the instructor on a smart phone (12)
- _____ Taking photos with your smart phone/tablet to reference later (13)

- _____ Recording the lecture on any device (14)
- _____ Writing on an electronic tablet (i.e., an iPad) (15)

Q25 Please rank your top 3 preferred note-taking practices during an **online or recorded** lecture or course. Please enter **1** for your first choice, **2** for your second choice, and **3** for your third choice.

- _____ Pen and blank paper (1)
- _____ Pen and printed handouts provided by the instructor (8)
- _____ Typing on a laptop (9)
- _____ Annotating documents or textbook provided by the instructor on a laptop (10)
- _____ Annotating documents or textbook provided by the instructor on a tablet (11)
- _____ Annotating documents or textbook provided by the instructor on a smart phone (12)
- _____ Taking photos with your smart phone/tablet to reference later (13)
- _____ Recording the lecture on any device (14)
- _____ Writing on an electronic tablet (i.e., an iPad) (15)

Q26 What influences your decision to take notes in a certain way?

Q27 Select the locations where you might use your **smart phone** for academic purposes. (Select all that apply.)

- In the classroom (1)
- Campus library (4)
- Elsewhere on campus (5)
- At home in a private space (6)
- At home in a living room or communal space (7)

- At work (8)
- While traveling (i.e., on the bus) or walking (9)
- Public library not on campus (10)
- Coffee shop or other public space (11)
- On a trip away from home and campus (12)

Q28 How often do you use your **smart phone** for academic purposes in each of the following locations? (Options: Frequently, Sometimes, Rarely)

- In the classroom (x1)
- Campus library (x4)
- Elsewhere on campus (x5)
- At home in a private space (x6)
- At home in a living room or communal space (x7)
- At work (x8)
- While traveling (i.e., on the bus) or walking (x9)
- Public library not on campus (x10)
- Coffee shop or other public space (x11)
- On a trip away from home and campus (x12)

Q29 On a scale of 1-5, where 1 is Strongly Disagree and 5 is Strongly Agree, please rate each of the following statements.

- There are times when I need to use my smart phone for academic work. (1)
- I perform academic work on my smart phone when I am away from home or school. (2)
- I don't like using my smart phone for academic work. (3)
- I am able to perform the academic tasks I need to on my smart phone. (10)

- I would use my smart phone for academic work more if the materials were formatted for it. (11)
- I think having access to my course materials on my smart phone would help me succeed in achieving my degree. (12)
- My instructors understand how I use my smart phone. (13)

Q48 Were you enrolled on any Indiana University campus (including Indianapolis, Columbus, and Fort Wayne) during the 2020-2021 academic year (i.e. the last school year)?

- Yes (1)
- No (2)

Q49 What best describes your usage of your smart phone for learning during the COVID-19 pandemic?

- Much more than normal (1)
- Somewhat more than normal (2)
- About the same (3)
- Somewhat less than normal (4)
- Much less than normal (5)

Q50 Do you live on- or off-campus?

- On-campus (1)
- Off-campus (2)

Q51 Do you have a private study space at your home or place of residence (i.e., a private, unshared place or single dorm room)?

- Yes (1)

- No (2)

Q52 Do you have high-speed internet at your place of residence?

- Yes (1)
- No (2)
- I don't know (3)

Q53 How many hours per week do you work for pay?

- 0 (1)
- 1-10 (2)
- 11-20 (3)
- 21-39 (4)
- 40 or more (5)

Appendix B – Survey Instrument for Anonymous Student Survey (Group 2)

Q0 I acknowledge that I would like to take part in this survey and that I am at least 18 years old.

- Yes (1)
- No (2)

Q1 Please check all the devices that you own or regularly use:

- A "basic" mobile phone (a phone which CANNOT install apps) (1)
- A "smart" mobile phone (a phone which CAN install apps) (2)
- An e-reader (an electronic reading device that CANNOT install apps) (3)
- A tablet (a portable electronic tablet that CAN install apps, including iPad) (4)
- A laptop computer (including Microsoft Surface) (5)
- Chromebook (6)
- A desktop computer (7)

Q2 Do you have an unlimited data plan for your mobile phone?

- Yes (1)
- No (2)
- I don’t know (3)

Q3 What is the operating system for your smart phone?

- Apple iOS (1)
- Google Android (2)
- Other (3)
- I don’t know (4)

Q4 What is the operating system for your tablet?

- Apple iOS/iPadOS (1)
- Google Android (i.e., Samsung tablets) (2)
- Amazon Kindle Android (i.e., Kindle Fire tablets) (3)
- Other (4)
- I don't know (5)

Q5 Do you have an external monitor that you use with your laptop or Chromebook?

- Yes, 1 external monitor (1)
- Yes, 2 external monitors (2)
- No (3)

Q6 How many monitors does your desktop computer have?

- 1 monitor (1)
- 2 monitors (2)
- 3+ monitors (3)

Q7 Which of the following apps do you have installed **on your smart phone**? (Select all that apply)

- IU Mobile (1)
- Canvas Student app (known as "Student") (2)
- TopHat (3)
- Boost (4)
- Unizin Read (5)

- Quizlet (6)
- VoiceThread (7)
- Microsoft Office (23)
- Microsoft OneDrive (20)
- Microsoft Word (8)
- Microsoft PowerPoint (9)
- Microsoft Excel (10)
- Microsoft OneNote (24)
- Microsoft Teams (11)
- Google Drive (12)
- Google Docs (13)
- Google Slides (14)
- Google Sheets (15)
- Discord (16)
- GroupMe (17)
- Zoom (18)

Q8 Which of the following the apps are you aware of but **do not** use **on your smart phone**? (Select all that apply.)

- IU Mobile (1)
- Canvas Student app (known as “Student”) (2)
- TopHat (3)
- Boost (4)
- Unizin Read (5)

- Quizlet (6)
- VoiceThread (7)
- Microsoft Office (8)
- Microsoft OneDrive (9)
- Microsoft Word (10)
- Microsoft PowerPoint (11)
- Microsoft Excel (12)
- Microsoft OneNote (13)
- Microsoft Teams (14)
- Google Drive (15)
- Google Docs (16)
- Google Slides (17)
- Google Sheets (18)
- Discord (19)
- GroupMe (20)
- Zoom (21)

Q9 If you have installed other smart phone or tablet apps that you use for academic work, please list them here:

Q29 On a scale of 1-5, where 1 is Strongly Disagree and 5 is Strongly Agree, please rate each of the following statements.

- There are times when I need to use my smart phone for academic work. (1)
- I perform academic work on my smart phone when I am away from home or school. (2)

- I don't like using my smart phone for academic work. (3)
- I am able to perform the academic tasks I need to on my smart phone. (10)
- I would use my smart phone for academic work more if the materials were formatted for it. (11)
- I think having access to my course materials on my smart phone would help me succeed in achieving my degree. (12)
- My instructors understand how I use my smart phone. (13)

Q30 How do you read books that are **not related** to school? (Select all that apply.)

- Physical books (1)
- Smart phone (4)
- E-Reader (i.e., a Kindle) (5)
- Tablet (6)
- Laptop/Desktop (7)
- Audiobook (8)
- I do not read books for pleasure (9)

Q31 Given a choice, and assuming the technology works as you would like it to, what is your preferred way to read books **for pleasure**? (Select one)

- Physical books (1)
- Smart phone (4)
- E-Reader (i.e., a Kindle) (5)
- Tablet (6)
- Laptop/Desktop (7)
- Audiobook (8)

Q32 What are the different ways you have read textbooks **for school**? (Select all that apply)

- Physical books (1)
- E-Text on smart phone (9)
- E-Text on E-Reader (i.e., a Kindle) (10)
- E-Text on tablet (11)
- E-Text on laptop/desktop (12)
- Audiobook (13)

Q33 Given a choice, and assuming the technology works as you would like it to, what is your preferred way to read books **for school**? (Select one)

- Physical books (1)
- Smart phone (4)
- E-Reader (i.e., a Kindle) (5)
- Tablet (6)
- Laptop/Desktop (7)
- Audiobook (8)

Q34 What is your experience and opinion about using e-texts **for school**?

Q35 How do you watch video content (i.e., YouTube, Twitch) that is **not related to school**? (Select all that apply)

- TV with streaming device/capability (1)
- Smart phone (4)

- Tablet (5)
- Laptop/Desktop (6)
- Other (please specify on the next page) (7)

Q36 Please describe how else you watch video content that is **not related to school**

Q37 How do you watch recorded video content **for school**? (Select all that apply)

- TV with streaming device/capability (1)
- Smart phone (4)
- Tablet (5)
- Laptop/Desktop (6)
- Other (please specify on the next page) (7)

Q38 Please describe how else you watch recorded video content **for school**

Q39 Given a choice, and assuming the technology works as you would like it to, what is your preferred way to watch recorded video content for school while **at home or in your dorm**? (Select one)

- TV with streaming device/capability (1)
- Smart phone (4)
- Tablet (5)
- Laptop/Desktop (6)
- Other (please specify on the next page) (7)

Q40 Please describe your preferred way to watch recorded video content for school while **at home or in your dorm**

Q41 Given a choice, and assuming the technology works as you would like it to, what is your preferred way to watch recorded video content for school while **away from home**? (Select one)

- TV with streaming device/capability (1)
- Smart phone (4)
- Tablet (5)
- Laptop/Desktop (6)
- Other (please specify on the next page) (7)

Q42 Please describe your preferred method to watch recorded video content for school while **away from home**

Q43 Have you ever had an instructor at IU who explicitly did ***NOT*** allow mobile devices (phones or tablets) to be used during class?

- Yes (1)
- No (2)
- I don't know (3)

Q44 Have you ever had an instructor at IU who explicitly did ***NOT*** allow laptop computers to be used during class?

- Yes (1)

- No (2)
- I don't know (3)

Q48 Were you enrolled on any Indiana University campus (including Indianapolis, Columbus, and Fort Wayne) during the 2020-2021 academic year (i.e. the last school year)?

- Yes (1)
- No (2)

Q49 What best describes your usage of your smart phone for learning during the COVID-19 pandemic?

- Much more than normal (1)
- Somewhat more than normal (2)
- About the same (3)
- Somewhat less than normal (4)
- Much less than normal (5)

Q50 Do you live on- or off-campus?

- On-campus (1)
- Off-campus (2)

Q51 Do you have a private study space at your home or place of residence (i.e., a private, unshared place or single dorm room)?

- Yes (1)
- No (2)

Q52 Do you have high-speed internet at your place of residence?

- Yes (1)
- No (2)
- I don't know (3)

Q53 How many hours per week do you work for pay?

- 0 (1)
- 1-10 (2)
- 11-20 (3)
- 21-39 (4)
- 40 or more (5)

Appendix C – Initial Questions for Student Focus Groups

- How often do you access Canvas using your smart phone?
- Do you use the Canvas Student app or a web browser?
- What do you like most about the Canvas Student mobile app?
- What do you like least about the Canvas Student mobile app?
- What's your preferred way to take notes in class?
- What's your preferred way to take notes while studying or watching online/recorded lectures?
- When working on academic work on campus but outside of class, what devices do you use?
- When working on academic work at home or off campus, what devices do you use?
- How do you read books for pleasure?
- How do you read for classes?

Appendix D – Email Request for Additional Information from Students Who Could Not Participate in Focus Groups

Hello!

This message is related to the Student Use of Personal Technology for Academic Work project at HU. Thank you for agreeing to answer a few questions via email. I know your time is valuable and I appreciate your feedback. You can simply respond to this message with your thoughts.

The goal of this project is to investigate student personal technology and preferences to inform IU during the instructional technology selection process. We are particularly interested in how (and if) you use your *mobile* devices for schoolwork, but nothing is off the table – I want to learn what you like, what you hate, and what you think is missing that might help you succeed at IU. Your responses are completely confidential!

I will post a list of "starter" questions below. Please feel free to choose any that you would like to answer. You're also welcome to submit any additional thoughts you might have.

For your information to be included in the study, please respond by November 8th!

Thank you very much for your time.

Rob

Starter questions: Feel free to pick and choose those you'd like to answer!

- What activities do you tend to do when you are using Canvas with your smart phone?
- When do you use the Canvas Student app?
- When do you use Canvas by web browser?
- What influences your decision to use the app or browser instead of the other?
- What do you like *most* about the Canvas Student mobile app?
- What do you like *least* about the Canvas Student mobile app?

- What schoolwork or studying do you wish you could do with your smart phone that you feel you cannot?
- With regard to technology, is there anything you wish instructors would do better? For example, do you want them to provide handouts or organize their courses differently?
- With regard to technology, is there anything you've had an instructor do that was particularly helpful to you?
- Please feel free to add any additional thoughts or questions you might have about using your mobile device and other personal technology for your academic work at HU.

Appendix E – Sample Canvas Log Record


```
{
 "@context": "http://purl.imsglobal.org/ctx/caliper/v1p1",
 "id": "urn:uuid:4cc3f79b-c6d5-433a-a3aa-3b719137001c",
 "type": "NavigationEvent",
 "actor": {
  "id": "urn:instructure:canvas:user:290000006302554",
  "type": "Person",
  "extensions": {
   "com.instructure.canvas": {
    "user_login": "boostapi",
    "user_sis_id": "boostapi@iu.edu",
    "root_account_id": "290000000098865",
    "root_account_lti_guid": "c78f545d267dc4eeb0760055b03e924978aac765.iu.instructure.com",
    "root_account_uuid": "xeUh4Sb6srT9hSaqZzNMKx9ylLjJ3BmmTHzzmQDj",
    "entity_id": "290000006302554"
   }
  }
 },
 "action": "NavigatedTo",
 "object": {
  "id": "urn:instructure:canvas:course:290000001832718",
  "type": "Entity",
  "name": "assignments",
  "extensions": {
   "com.instructure.canvas": {
    "asset_name": "FA19: CIT 21300 (MW) 24814",
    "asset_type": "course",
    "asset_subtype": "assignments",
    "entity_id": "290000001832718",
    "context_account_id": "290000000138409",
    "http_method": "GET",
    "developer_key_id": "170000000000016"
   }
  }
 },
 "eventTime": "2019-11-20T11:04:43.882Z",
 "edApp": {
  "id": "http://iu.instructure.com/",
  "type": "SoftwareApplication"
 },
 "group": {
  "id": "urn:instructure:canvas:course:290000001832718",
  "type": "CourseOffering",
  "extensions": {
   "com.instructure.canvas": {
    "context_type": "Course",
```

```
      "entity_id": "290000001832718"
     }
    }
   },
   "membership": {
    "id": "urn:instructure:canvas:course:290000001832718:user:290000006302554",
    "type": "Membership",
    "member": {
     "id": "urn:instructure:canvas:user:290000006302554",
     "type": "Person"
    },
    "organization": {
     "id": "urn:instructure:canvas:course:290000001832718",
     "type": "CourseOffering"
    }
   },
   "extensions": {
    "com.instructure.canvas": {
     "hostname": "iu.instructure.com",
     "request_id": "60192c4d-59e4-4f44-9a73-c7d43de73663",
     "user_agent": "axios/0.18.0",
     "client_ip": "3.133.148.84",
     "request_url":
"https://iu.instructure.com/api/v1/courses/1832718/assignments?bucket=upcoming?per_page=100&b
ucket=upcoming&override_assignment_dates=false",
     "version": "1.0.0"
    }
   }
}
```

Appendix F – Database Schema of Transformed Canvas Log Data

Field	Data Type	Notes
id	STRING	
course_offering_id	STRING	
user_sis_id	STRING	Student ID that allowed connection to demographic data (replaced with random identifier to protect student identity.)
asset_type	STRING	
asset_subtype	STRING	
asset	STRING	Combination of asset_type and asset_subtype fields that holds the specific LMS activity being performed.
user_agent	STRING	String that specifies which application or browser was used to retrieve data.
request_url	STRING	
device	STRING	Macintosh, Windows, Android, iOS, or Other
platform	STRING	Mobile or Desktop
previous_event	TIMESTAMP	Previous event in session; NULL if this event is first in session
event_time	TIMESTAMP	Time of event
next_event	TIMESTAMP	Next event in session; NULL if this event is last in session
time_on_task	INTEGER	Time between current event and next event in milliseconds; NULL if this event is last in session
session_id	INTEGER	
event_order	INTEGER	

Appendix G – Sample Record of Canvas Log Data Relational Database Table

Field	Data
id	4870e0a0-88b6-4b64-baf1-f2a0ba7dd275
course_offering_id	1849195
user_sis_id	XXXXXX12345
asset_type	course
asset_subtype	modules
asset	course modules
user_agent	Mozilla/5.0 (Macintosh; Intel Mac OS X 10_14_6) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/76.0.3809.100 Safari/537.36
request_url	https://iu.instructure.com/courses/1849195/modules
device	Macintosh
platform	Desktop
previous_event	8/28/2019 01:10:24
event_time	8/28/2019 01:10:25
next_event	8/28/2019 01:10:32
time_on_task	7380
session_id	1
event_order	4

Appendix H – Applications Available to be Installed on Student Mobile Devices

A list of mobile applications available to be installed at no cost to students at Hudson University.

- HU Mobile (internal university information portal)
- Canvas Student app (known as “Student”)
- TopHat
- Boost
- Unizin Read
- Quizlet
- VoiceThread
- Microsoft Office
- Microsoft OneDrive
- Microsoft Word
- Microsoft PowerPoint
- Microsoft Excel
- Microsoft OneNote
- Microsoft Teams
- Google Drive
- Google Docs
- Goodle Slides
- Discord
- GroupMe
- Zoom

Appendix I – Academic Activities Classified According to Park's Pedagogical Framework

Students were asked about 29 specific academic activities and how they perceived performing these activities on their mobile devices. These academic activities have been organized according to the four types of activities classified by Park's Pedagogical Framework for Mobile Learning (2011).

Type 1: High Transactional Distance/Socialized Mobile Learning Activity

1. Read or reference notes/handouts
2. Read Canvas pages
3. Watch classroom recording
4. Send or respond to Canvas inbox w/ instructor
5. Send or respond to IU email w/ instructor
6. Send or respond to direct message w/ instructor
7. Send or respond to a text message w/ instructor
8. Participate in graded discussion exercise

Type 2: High Transactional Distance/Individualized Mobile Learning Activity

9. View course announcements
10. View Canvas calendar
11. View Canvas to-do list
12. View course roster
13. See push notifications
14. Review assignment requirements
15. Review due dates
16. Review grades
17. Read or reference textbook
18. Watch assigned video

19. Record introductory video
20. Listen to assigned podcast/audio

Type 3: Low Transactional Distance/Socialized Mobile Learning Activity

21. Take photos of whiteboards or class activities
22. Take video of whiteboards, lectures, or class activities
23. Make audio recording of lecture or class activity

Type 4: Low Transactional Distance/Individualized Mobile Learning Activity

24. Take notes
25. Take photos of course materials
26. Take a short quiz
27. Write a short essay
28. Take an exam
29. Write an academic paper

Curriculum Vitae

Rob Elliott

Education

- Ed.D. Instructional Systems Technology, Indiana University (2022)
- M.S. Human-Computer Interaction, Indiana University Purdue University Indianapolis (2009)
- B.S. Computer Information Technology, Indiana University Purdue University Indianapolis (2000)

Academic Appointments

- IUPUI, Teaching Professor, Department of Computer Information and Graphics Technology, 2021 – present, full time.
- IUPUI, Senior Lecturer, Department of Computer Information and Graphics Technology, 2018 – 2021, full time.
- IUPUI, Lecturer, Department of Computer Information and Graphics Technology, 2012 – 2018, full time.
- IUPUI, Visiting Lecturer, Department of Computer Information and Graphics Technology, 2009 – 2012, full time.
- IUPUI, Visiting Lecturer, Department of Computer Information and Graphics Technology, 2003 – 2009, part time.

Non-Academic Experience

- Owner, instrux LLC, 2009 – 2019
- Creator, Red Cross Online Training, American Red Cross of Greater Indianapolis, 2007 – 2009
- Multimedia Developer, Willow Marketing, 2000 – 2007

Honors and Awards

- Indiana University President's Award for Distinguished Teaching, 2020
- Trustee's Teaching Award, Division of Undergraduate Education, IUPUI, Indianapolis, IN, 2019

- FACET Academy Award for Excellence in Teaching with Collaborative Activities, Indiana University Faculty Academy on Excellence in Teaching, 2017
- Chancellor's Award for Excellence in Teaching, IUPUI, Indianapolis, IN, 2016
- Trustee's Teaching Award, Purdue School of Engineering and Technology, IUPUI, Indianapolis, IN, 2016
- Outstanding Teacher Award, Purdue School of Engineering and Technology, IUPUI, Indianapolis, IN, 2015
- Best Paper Award for "Analysis of Student Perceptions and Behaviors in a Flipped Classroom Undergraduate Information Technology Course", CIT Division, 2014 ASEE Annual Conference, Indianapolis, IN.

Courses Taught

Undergraduate

- CIT 14000 Programming Constructs Lab
- CIT 21300 Systems Analysis and Design
- CIT 24200 Introduction to ASP.NET Programming
- CIT 30500 Android Native Application Development
- CIT 37300 Visual Design for Software
- CIT 37400 Systems & Database Analysis
- CIT 40700 Fundamentals of Intelligent Agents
- CIT 41100 iOS Mobile Application Development
- CIT 41200 Data-Driven Cloud Applications
- CIT 41600 Global IT
- CIT 43600 Advanced e-Commerce Development

Graduate

- CIT 50101 iOS Application Development
- CIT 50102 Android Application Development
- TECH 58100 Data-Driven Cloud Applications
- TECH 58100 e-Commerce Development
- TECH 58100 Global IT

Publications and Presentations

Papers in Refereed Conference Proceedings

Elliott, R. & Luo, X. (2020). *Demonstrating the Impact of International Collaborative Disciplinary Experiences on Student Global, International, and Intercultural Competencies.* 2020 Frontiers in Education Conference, Uppsala, Sweden, October 21-24.

Elliott, R., & Luo, X. (2018). *Improving the Global, International and Intercultural (GII) Competencies of IT Students via Integrated Collaboration During Study Abroad.* In Proceedings of the 19th Annual SIG Conference on Information Technology Education (pp. 50–55). New York, NY, USA: ACM. https://doi.org/10.1145/3241815.3241858

Elliott, R. (2014). *Analysis of Student Perceptions and Behaviors in a Flipped Classroom Undergraduate Information Technology Course.* Proceedings of the 2014 ASEE Annual Conference, Indianapolis, IN, June 15-18.

Elliott, R. (2014). *Do Students Like the Flipped Classroom? An Investigation of Student Reaction to a Flipped Undergraduate IT Course.* Proceedings of the 2014 Frontiers in Education Conference, Madrid, Spain, October 22-25.

Elliott, R. (2011). *Work in Progress – The Impact of Integrating First-Year Students into the Broader Curriculum.* Proceedings of the 2011 Frontiers in Education Conference, Rapid City, SD, October 22-25.

Presentations at International and National Professional Meetings

Renguette, C., Meacham, H., Ghebrenegus, N. & Elliott, R. (2021, October 28). *Intercultural Collaboration: Engaging Distant Students in Virtual Activities.* International Virtual Exchange Conference 2021.

Elliott, R., Zhao, H., & Ricke, A. (November 9, 2018). *USDA Choice: Using Student Devices Advantageously.* Presented at the 2018 IU Online Conference in Indianapolis, Indiana.

Elliott, R., & Luo, X. (October 22, 2018). *Evaluating Multi-Institution Student Collaboration Via Study Abroad.* Presented at the 2018 Assessment Institute in Indianapolis, Indianapolis, Indiana.

Birdwell, T., Elliott, R., & Evans, N. (November 17-19, 2017). *Mosaic Faculty Fellows: An FLC for Institutional Change.* Presentation at the Lilly International Conference on Teaching and Learning, Oxford, OH.

Elliott, R., Evans, N., & Ingram, E. (November 18-20, 2016). *A Process of Institutional Change in Online Learning.* Presentation at the Lilly International Conference on Teaching and Learning, Oxford, OH.

Elliott, R., Evans, N., & Zhao, H. (November 19-22, 2015). *Classroom Technology from the Students' Perspective.* Presentation at the Lilly International Conference on Teaching and Learning, Oxford, OH.

Elliott, R. (November 20-23, 2014). *Analysis of Student Perceptions of a Flipped Classroom Undergraduate Information Technology Course.* Poster at the Lilly International Conference on Teaching and Learning, Oxford, OH.

Elliott, R., & Evans, N. (November 20-23, 2014). *Doing Backflips in the Classroom: A Scaffold for the Flipped Classroom.* Presentation at the Lilly International Conference on Teaching and Learning, Oxford, OH.

Elliott, R., & Evans, N. (November 20-23, 2014). *Technology Tools to Improve Engagement and Interactivity in Online Courses.* Presentation at the Lilly International Conference on Teaching and Learning, Oxford, OH.

Elliott, R., & Evans, N. (May 14-16, 2014). *Time to Fail in Flipped Classrooms: Learning Environments that Allow Mistakes and Encourage Risk.* Presentation at the Great Lakes Conference on Teaching and Learning, Mt. Pleasant, MI.

Elliott, R., & Evans, N. (November 21-24, 2013). *Practical Considerations for Flipping a Classroom.* Presentation at the Lilly International Conference on Teaching and Learning, Oxford, OH.

Elliott, R. (2011). *Divide and Conquer: Incorporating Large-Scale Project Development Throughout the Curriculum.* Poster presented at the annual meeting of the Coalition of Urban and Multicultural Universities, Indianapolis, IN.

Defazio, J., Elliott, R., Hardin, J. (2011). *There's An App For That: Supporting Eco-Conscious Communities via Location-based Networking.* Poster presented at the annual meeting of the Coalition of Urban and Multicultural Universities, Indianapolis, IN.

Service Activities

- President-Elect, Purdue School of Engineering and Technology Faculty Senate (2021 – present)
- Co-Chair, IUPUI Virtual Exchange Community of Practice (2020 – present)
- Member, Learning Technologies Steering Committee, Indiana University (2020 – present)

- Campus Co-Liason, Indiana University Faculty Academy for Excellence in Teaching (FACET) (2019 – present)
- Unit Representative, IUPUI Faculty Council (2019 – present)
- Steering Committee Member, Indiana University Faculty Academy for Excellence in Teaching (FACET) (2017 – present)
- Undergraduate Academic Advisor (20 students) (2012 – present)