

DESIGNING MOBILE LEARNING EXPERIENCES WITH MICROLEARNING
VIDEO LESSONS

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ABSTRACT

Mobile learning has become increasingly popular among college students due to its convenience and portability. However, the small screen size of mobile devices poses challenges for effective learning. While mobile learning research has focused on various frameworks, a standardized set of guidelines for effective mobile learning does not exist. Microlearning, an approach commonly used in workplace training, has the potential to address this gap in mobile learning design. This case study examines the effectiveness of the Designing for One - Microlearning Design and Development (DO-MDD) framework in higher education, specifically for programming courses. The study explores the experiences of instructors who designed microlearning video lessons using the DO-MDD framework and assesses students' learning experiences with those lessons. Findings indicate that instructors and students valued the framework for its ability to focus content on a single learning objective, which positively affected student engagement and focus. However, challenges related to video length and the provision of immediate feedback emerged. These challenges suggest areas for improvement, including integrating real-time feedback and adapting the framework for other academic disciplines. Future research should explore how the DO-MDD framework can be refined to address these issues and expanded to broader educational contexts.

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CHAPTER 1. INTRODUCTION

Mobile devices have become an integral part of daily life for many individuals (Oliveira et al., 2021; Svalina et al., 2023), particularly college students, who frequently use them to access educational content due to their convenience and portability (Biswas et al., 2020; Golenhofen et al., 2020; Nikou & Economides, 2018a; NMC Horizon Report, 2017). While these devices offer flexibility for learning on the go, their small screen sizes present challenges in delivering effective learning experiences (Al-Hunaiyyan et al., 2018; Faudzi et al., 2024; Gong & Tarasewich, 2004; Prasad, 2020). Despite the increasing focus on mobile interface design, a standardized set of guidelines has yet to emerge (Gong & Tarasewich, 2004; Li & Luximon, 2020; Punchoojit & Hongwarittorn, 2017). Microlearning, an instructional approach that has gained traction in workplace training (Corbeil et al., 2021; Lee, Jahnke, & Austin, 2021b), was developed to meet the need for accessible just-in-time learning (Hogle, 2021; Inker et al., 2021; Lee et al., 2021b). Research has shown that participants in workplace training favored the accessibility of microlearning when delivered through mobile devices (Hall, 2021; Heydari et al., 2019). Given its adaptability, microlearning has the potential to address the gap in mobile learning design research by serving as a framework for developing effective mobile learning lessons.

Statement of the Problem

Existing research has contributed to the growth of mobile learning classroom implementation through a range of proposed frameworks, each focused on specific features of mobile learning (Dennen & Hao, 2014; Koole, 2009; Vavoula & Sharples, 2009). Mobile learning research spans across topics such as learner experience (Koole, 2009; Parsons et al., 2007; Vavoula & Sharples, 2009), portability (Dennen & Hao, 2014; Koole, 2009), instructional strategies (Dennen & Hao, 2014), mobile interface design (Al-Hunaiyyan et al., 2018; Gong & Tarasewich, 2004; Prasad, 2020) and the learner's cognitive load (Almasseri & AlHojailan, 2019; Beukes, 2019; Lohr, 2000; Mayer, 2008; Mayer, 2021a; Mayer, 2021b; Mayer, 2024).

Other areas of research suggest that multimedia learning and instructional design can support mobile learning design (Alyahya & Nasser, 2019; Ofori & Lockee, 2021). However,

Ofori and Lockee (2021) emphasize the lack of evidence-based recommendations for mobile learning message design and highlight the need to further explore mobile learning pedagogy and mobile learning design (Corbeil et al., 2023; Grant, 2019; Salhab & Daher, 2023; Sarrab et al., 2013; Sarrab et al., 2018; Sharma et al., 2016; Tlili et al., 2024). To address this gap, microlearning, an emerging trend in workplace training (Corbeil et al., 2021; Lee et al., 2021b), has the potential to function as a framework for designing mobile learning for mobile devices.

Microlearning, defined as brief, just-in-time targeted lessons (Jahnke et al., 2020; Torgerson & Iannone, 2020), was developed to cater to learners seeking accessible training that fit into their busy schedules (Hogle, 2021; Inker et al., 2021; Lee et al., 2021b). Due to this need, there has been an increase in microlearning in workplace training research (Corbeil et al., 2021; Lee et al., 2021b), which has indicated that microlearning-designed training effectively enhances knowledge retention, helping employees to apply the information they learned (Inker et al., 2021; Leong et al., 2021). Although microlearning has become popular in workplace training environments, there remains a gap in how microlearning-designed lessons can be applicable to academic mobile learning research (Dolasinski & Reynolds, 2020).

Despite the growth in mobile learning design research, research still lacks evidence-based recommendations specific to designing mobile learning for mobile devices (Ofori and Lockee, 2021) with a specific set of design principles. Microlearning research could help to contribute to this gap in academic research regarding mobile learning design. Workplace training research has shown that microlearning-designed training for mobile devices were favored by participants due to accessibility (Hall, 2021; Heydari et al., 2019), having the ability to rewatch videos (Wang et al., 2021; Zheng, 2021), and reduced training time (Hall, 2021). Other research has shown improved learner motivation (Lee, 2021a; Nikou & Economides, 2018b) and knowledge retention (Boring, 2020; Lee, 2021a; Lee et al., 2021b) by learners who learned with microlearning-designed lessons. Gaining a better understanding of how college learners could benefit from microlearning-designed lessons will help to provide insights to design principles specific to designing mobile learning for mobile devices.

Purpose

To address the gap in mobile learning design research, the Designing for One - Microlearning Design & Development (DO-MDD) framework was developed as the conceptual framework for this study. The purpose of this case study was to evaluate whether the DO-MDD framework is an effective tool for designing microlearning lessons for mobile learning. Both qualitative and quantitative data were collected to explore the experiences of instructors and their students. More specifically, the study examined: 1) instructors' experiences creating and implementing video lessons using the framework, and 2) students' experiences learning with those lessons.

Research Questions

To examine the effectiveness of the DO-MDD framework, this study investigated its application in higher education programming courses. The participants included three higher education instructors who designed microlearning lessons using the DO-MDD framework, and their students who used the DO-MDD designed lessons. This study was guided by the following research questions:

1. How did the instructors use the DO-MDD framework?
2. What are the instructors' perceptions of the DO-MDD framework?
3. What are the instructors' perceptions of students' learning using the lessons designed based on the DO-MDD framework?
4. What are students' perceptions of lessons based on the DO-MDD framework?
5. How do lessons based on the DO-MDD framework hinder/enhance student learning?

Significance of the Study

Due to advancements in mobile technology, there has been a growing trend in utilizing mobile devices in education. Despite the convenience, the small screen size has posed challenges for learning on the go (Al-Hunaiyyan et al., 2018; Gong & Tarasewich, 2004; Prasad, 2020). To address these challenges, a variety of frameworks have been developed for mobile learning (Dennen & Hao, 2014; Koole, 2009; Vavoula & Sharples, 2009), and there have been efforts focused on mobile learning interface design challenges (Al-Hunaiyyan et al., 2018; Gong &

Tarasewich, 2004; Prasad, 2020). However, literature still lacks a specific set of empirically researched design principles for effective mobile learning design.

Recognizing this gap in literature, this study aims to explore the potential of microlearning as a design framework for mobile learning. Specifically, this study may provide practical contributions by helping higher education instructors recognize the advantages of designing microlearning lessons to enable students to learn anytime and anywhere with portable devices (Diaz Redondo et al., 2020; Hanshaw & Hanson, 2018; Lee et al., 2021b; Shail, 2019).

Theoretically, this study explores whether microlearning lessons designed with the DO-MDD framework could effectively support college students' mobile learning needs. Furthermore, this study has the potential to provide new insights into how college learners could benefit from short, focused designed lessons. Microlearning, for the context of this study, is defined as learning content focused on a single learning objective (Alqarni, 2021; De Gagne et al., 2019; Leong et al., 2021; Shail, 2019) that can be consumed in 15 minutes or less (De Gagne et al., 2019; Diaz Redondo et al., 2020; Leong et al., 2021).

Conceptual Framework

Microlearning, often seen in workplace training research (Corbeil et al., 2021; Lee et al., 2021b), has been effective in reducing cognitive load (De Gagne et al., 2019; Shail, 2019; Wang et al., 2021) and facilitating knowledge retention (Inker et al., 2021; Leong et al., 2021). Despite its success, there is limited research that incorporates microlearning (Zhang & West, 2020), especially in academic research (Dolasinski & Reynolds, 2020). This study's conceptual framework draws from ADDIE, Dolasinski and Reynolds's (2020) Microlearning Model, and Jahnke et al.'s (2020) Four Instructional Flow model as shown in Figure 2. Figure 2, the DO-MDD framework was used to design mobile learning lessons for college programming courses. The focus of this study was to examine the DO-MDD framework's potential to serve as a guiding model for designing mobile learning. The conceptual framework for this study is described in more detail in Chapter 2 and 3.

Summary of Methodology

This study utilized a case study approach. This case study involved the collection of multiple sources of qualitative data and quantitative data to obtain a closer examination of the study (Thomas, 2021; Yin, 2018). Qualitative data were collected through open-ended questions of an online student questionnaire, instructor interviews, student interviews, instructor self-reflective journals, and researcher video observations to understand instructor and student perceptions, as well as the outcomes from their experiences with microlearning videos created with the DO-MDD framework. Quantitative data were collected through an online student questionnaire, student learning data, and student behavior data. The methodology is described in more detail in Chapter 3.

Assumptions, Delimitations, and Limitations

This study was built upon several assumptions to guide the research and ensure feasibility. A key assumption was that instructors possessed the necessary skills to create microlearning lessons using the DO-MDD framework, and students could access and navigate microlearning video lessons on mobile devices. It was also assumed that students would fully engage with the microlearning videos since this was essential for measuring the effectiveness of the DO-MDD framework. In addition, the study assumed that data collected from the participants would reflect honest experiences and perceptions. Lastly, it was assumed that the instructors followed the DO-MDD framework accurately and consistently across all microlearning video lessons created.

In addition to these assumptions, this study also includes several delimitations that define the study's scope and focus. First, the study is limited to three programming instructors and their students in a higher education setting, which limits the generalizability of the findings. Second, not all instructors participated for the same number of semesters, potentially affecting the comparability of the experiences. Third, this study involved instructors with diverse teaching experiences. One instructor taught exclusively face-to-face courses, while the other two had experience teaching face-to-face, online, and hybrid formats. Fourth, the use of Amazon eGift cards to encourage student participation could have influenced students to participate primarily for the incentive.

This study also acknowledges several limitations. The unregulated nature of the instructors' self-reflective journal entries potentially may have impacted the accuracy of their reflections. Another limitation is the varying number of microlearning videos created by each instructor could have led to differences in experiences with the DO-MDD framework. Furthermore, the Hawthorne Effect (Levitt & List, 2011) could have influenced student responses.

Definition of Key Terms

This study contains several key terms. The following definitions are provided to ensure clarity and understanding of these terms.

Designing for One - Microlearning Design & Development (DO-MDD) framework. Integrated microlearning design and development framework based on ADDIE, Jahnke et al.'s (2020) Four Instructional Flow and Dolasinski and Reynolds's (2020) Microlearning Model.

Mobile learning. Learning in different contexts, anytime and anywhere using mobile devices (Sarrab et al., 2018; Tu & Hwang, 2020).

Mobile learning devices. Portable or handheld wireless devices that allow a student to access their learning environment anytime or anywhere (Baldwin & Ching, 2019; Chen et al., 2021; Pebriantika et al., 2021). Examples of such technologies include tablets, laptops, and smartphones (Bai, 2019; Sarrab et al., 2018).

Message design. Placement of elements such as words, images, signs, and colors (Alyahya & Nasser, 2019; Mabachi et al., 2021; Sweller et al., 2019), that influences how the learner's mind recognizes information.

Microlearning. Any learning content focused on a single learning objective (Alqarni, 2021; De Gagne et al., 2019; Leong et al., 2021; Shail, 2019) that can be consumed in 15 minutes or less (De Gagne et al., 2019; Diaz Redondo et al., 2020; Leong et al., 2021).

Student behavior data. Click analytic data collected from YouTube Analytics.

Student learning data. Data collected from assignments and quiz results.

Summary

Mobile devices have become an essential tool for college students, offering portability and convenience for learning on the go (Biswas et al., 2020; Kumar et al., 2022; Nikou & Economides, 2018a; NMC Horizon Report, 2017). Despite their popularity, learning on mobile devices poses unique challenges (Al-Hunaiyyan et al., 2018; Gong & Tarasewich, 2004; Prasad, 2020). To address these challenges, researchers have developed various frameworks for mobile learning design, but widely accepted standards do not exist (Gong & Tarasewich, 2004; Li & Luximon, 2020; Ofori & Lockee, 2021; Punchoojit & Hongwarittorn, 2017). This study seeks to address this gap by exploring microlearning, a method already adopted in workplace training (Corbeil et al., 2021; Lee et al., 2021b), can be adapted as a framework for mobile learning. The insights gained from this study aim to offer instructors practical guidelines for designing mobile learning lessons based on microlearning principles.

CHAPTER 2. LITERATURE REVIEW

The trend of applying mobile devices in education has rapidly grown due to technological advances, improvements in access to technology, and the desire for just-in-time information. The growing need for accessibility has become an important topic in education, making mobile devices a popular tool students use to access and learn information. Despite the growing popularity, the size of the user interface of a mobile device provides challenges for on-the-go learning (Al-Hunaiyyan et al., 2018; Gong & Tarasewich, 2004; Prasad, 2020). There is mobile interface design research, but true standards for mobile user interface design does not exist (Gong & Tarasewich, 2004; Li & Luximon, 2020; Ofori & Lockee, 2021; Punchoojit & Hongwarittorn, 2017). Microlearning, a design approach to learning, can address this problem.

This review of literature is divided into four major sections: Mobile learning, mobile device user interface, message design, and microlearning.

Mobile Learning

Mobile learning is supported by devices such as laptops, smartphones, and tablets that allow individuals to interact and stay connected on the go (Alqarni, 2021; Kumar et al., 2022; Sarrab et al., 2018; Grant, 2019; Traxler, 2010; Voicu & Muntean, 2023). These technologies support ubiquitous learning, learning anytime, anywhere (Alqarni, 2021; Kumar et al., 2022; Sarrab et al., 2018; Traxler, 2010; Voicu & Muntean, 2023; Zhampeissova et al., 2020), and have become a popular way for students to learn and access information (Biswas et al., 2020; Kumar et al., 2022; Nikou & Economides, 2018a; NMC Horizon Report, 2017). Over the past decade, mobile learning has grown from research projects to full implementation in the classroom. Although there has been growth in mobile learning research, there is still a need to examine mobile learning pedagogy and mobile learning design (Corbeil et al., 2023; Grant, 2019; Salhab & Daher, 2023; Sarrab et al., 2013; Sarrab et al., 2018; Sharma et al., 2016; Tlili et al., 2024).

This section of the literature review will cover: background and history, evolution of mobile learning definitions, and mobile learning devices.

Background and History

Mobile learning can be traced back to the 1970s when Dynabook was proposed by a team led by Alan Kay at Xerox Palo Alto Research Center (Kay, 1972). Dynabook was a low-cost wireless handheld device inspired by educational theorists Jerome Bruner and Seymour Papert. The purpose of Dynabook was to allow learners to share their ideas (Kay, 1972). Kay's paper showed this concept through an illustration of two children linked wirelessly using Dynabooks outside while completing shared simulation games (Kay, 1972).

Technology at the time was not sufficient to construct a working Dynabook. However, four decades later technology had grown to have the ability to construct a Dynabook concept. In 2005, Mobilelearn became an early mobile learning project that focused on the development of learning outside the classroom (Da Bormida et al., 2003). What followed were a variety of pilots and projects in schools, colleges, universities and communities throughout the world (Gerrard, 2020; Kukulska-Hulme & Traxler, 2007; Spencer-Smith et al., 2019; Traxler, 2013).

As mobile learning became popular in methods and techniques used for eLearning, mobile learning devices quickly exposed their limitations (Traxler, 2010). Earlier personal digital assistants (PDAs) and mobile phones were limited in functionality at the time due to screen size, processor speed, and battery life (Traxler, 2010). As mobile technology evolved, mobile learning evolved and was able to offer learner-centered instruction (Traxler, 2016; Traxler, 2010).

Research has highlighted a variety of proposed frameworks that focus on different characteristics of mobile learning. Koole's (2009) Framework for the Rational Analysis of Mobile Education (FRAME) model offered insights to personal aspects of learning and technical aspects of a mobile device while learning. Vavoula and Sharples (2009) proposed M3, a three-level evaluation framework concerned with: usability (micro level), learning experience (meso level), and integration within existing educational and organizational institutions (macro level). Parsons et al. (2007) focused on design requirements that drew from narrative and game metaphors: generic mobile environment issues, mobile learning context issues, learning experience, and learning objectives. Traxler's research emphasized the importance of the learner's experience (Traxler, 2007, 2010), with particular focus on the importance of cultural context (Traxler, 2018), and less on the affordances of the mobile device. The M-COPE framework by Dennen and Hao (2014) focused on helping instructors and designers as they

engage in the design of mobile learning activities. The M-COPE framework concentrated on five elements of design: mobile, conditions, outcomes, pedagogy, and ethics. Although today's research has evolved over time by focusing on the different aspects of mobile learning, common themes still emerge. These themes include portability of device, mobility of the learner, interactivity, control, communication, and the importance of context (Alqarni, 2021; Aguayo et al., 2017; Kearney et al., 2012; Kumar et al., 2022; Sung et al., 2019; Voicu & Muntean, 2023).

Evolution of Mobile Learning Definitions

Just as how mobile learning research has evolved, the definition of mobile learning has also changed over time. Early research defined mobile learning as electronic learning that used mobile and wireless device technologies (Anani et al., 2008; Motiwalla, 2007). This definition focuses on online learning activities and the remote location of the learner. In later larger scale projects, mobile learning focused on the learner's mobility and ability to learn while not in a fixed location (Laouris & Eteokleous, 2005; McAndrew et al., 2007; Sharples et al., 2009). Current research has focused on mobile learning affording the ability of personalized learning anytime, anywhere (Alqarni, 2021; Baldwin & Ching, 2019; Kumar et al., 2022; McQuiggan et al., 2015; Traxler, 2016; Tu & Hwang, 2020; Voicu & Muntean, 2023). Researchers have defined and described mobile learning in different ways. All the definitions focus on mobility and flexibility in relation to eLearning. See Table 1 for the different definitions of mobile learning. Mobile learning can be defined as ubiquitous learning, learning anytime, anywhere, with the use of mobile technology (Alqarni, 2021; Churchill & Churchill, 2008; Kumar et al., 2022; McQuiggan et al., 2015; Sarrab et al., 2018; Sharples, 2000; Traxler, 2010; Traxler, 2016; Tu & Hwang, 2020; Voicu & Muntean, 2023; Yuen & Yuen, 2008), while e-learning involves learning with computer technologies (Clark & Mayer, 2008; Horton, 2006). Mobile technology refers to portable devices such as smartphones, tablets, laptops, and digital notebooks (Kumar et al., 2022; Voicu & Muntean, 2023). For the purpose of this study the definition of mobile learning is learning in different contexts, anytime and anywhere using mobile devices (Kumar et al., 2022; Sarrab et al., 2018; Tu & Hwang, 2020; Voicu & Muntean, 2023).

Table 1*Different Definitions of Mobile Learning Over Time*

Researcher	Definition	Mobile technology
Sharples, 2000	Learning from any location throughout a lifetime	Personal (handheld or wearable) computer systems
Laouris & Eteokleous, 2005	Increasing a learner's capability to physically move their own learning environment when they move; environment- and time independent pedagogy	Learner freely moving in his/her physical and virtual Environment
Traxler, 2005	Portable e-learning	Handheld or palmtop devices (mobile phones, smartphones, PDAs, perhaps tablet PCs and laptop PCs)
Motiwalla, 2007	Individualized (or personal) learning anytime and anywhere learning	Wireless phone and handheld devices (ex. PDAs and smart phones)
Parsons, Ryu, & Cranshaw, 2007	The learner has the ability to be in contact while outside of conventional communication spaces	Portable communication devices
Anani, Zhang & Li, 2008	Kind of e-learning anywhere at anytime	Mobile devices (PDAs, mobile phones, notebooks, tablet PCs, and smart phones)
Churchill & Churchill, 2008	Assist individuals to learn anytime, anywhere, by empowering them to self-learn and collaborate with others throughout the world	PDA technology (PDAs w/wireless network connectivity, mobile phones, cameras and a variety of add-on hardware extensions)
Koole, 2009	Process resulting from the convergence of mobile technologies, human learning capacities, and social interaction	Wireless, networked mobile devices

Researcher	Definition	Mobile technology
Vavoula & Sharples, 2009	Learning out of the available physical and social resources	Mobile technology
Traxler, 2010	Reaching across spatial and geographical distance and social, economic and culture distance	Virtual spaces
Dennen & Hao, 2014	The mobile platform is a delivery medium; Supports flexible use and movement through an environment	Mobile devices such as phones and tablets
McQuiggan, McQuiggan, Sabourin, & Kosturko, 2015	Anywhere, anytime learning enabled by instant access to information and driven by learner's motivation	Educational technologies
Sarrab, Al-Shihi, Al-Manthari, & Bourdoucen, 2018	Learning in different contexts, anytime and anywhere using portable devices	Mobile wireless computing technologies
Traxler, 2018	Learning with mobiles	Mobile devices (handheld and tablet computers, MP3 players, smartphones, mobile phones)
Tu & Hwang, 2020	Instructional approach to promote learning through mobile technologies where the learner is capable of anytime and anywhere learning	Mobile technologies with the incorporation of mobile devices (smart phones, notebooks, tablet computers, wearable devices)
Kumar, Osman, Sanmugam, & Rasappan, 2022	Use of portable devices for learning and communicating in a learning environment in and out of the classroom	Mobile devices such as smartphones and laptops
Voicu & Muntean, 2023	Flexible learning accessible in formal and informal learning environments	Personal mobile wireless devices such as smartphones, tablets, laptops, and digital notebooks

Mobile learning shares similar features to e-learning where both learning approaches embrace multimedia content and communication with other students (Horton, 2006; Voicu & Muntean, 2023). However, wireless flexibility of time and place sets mobile learning apart from

e-learning (Peters, 2007; Voicu & Muntean, 2023). There are also distinctive characteristics of mobile technology that creates a unique learning experience for mobile learning. These characteristics are (a) mobility—mobility of the learning, technology, and learning (Kumar et al., 2022; Sarrab et al., 2018; Sharples, 2000; Tu & Hwang, 2020; Voicu & Muntean, 2023); (b) instant connectivity—mobile device can access information anytime and anywhere (Churchill & Churchill, 2008; McQuiggan et al., 2015; Sharples, 2000; Voicu & Muntean, 2023); (c) portability—mobile device can be taken to any location (Churchill & Churchill, 2008; Dennen & Hao, 2014; Kumar et al., 2022; Sarrab et al., 2018; Sharples, 2000; Vavoula & Sharples, 2009; Traxler, 2018; Voicu & Muntean, 2023); and (d) context sensitivity—mobile device can find and gather data (Churchill & Churchill, 2008; Parsons et al., 2007; Sarrab et al., 2018; Sharples, 2000; Tu & Hwang, 2020; Voicu & Muntean, 2023).

Mobile Learning Devices

Mobile learning currently explores technology such as tablets, laptops, digital notebooks, and smartphones (Bai, 2019; Kumar et al., 2022; Sarrab et al., 2018; Voicu & Muntean, 2023). These technologies are portable or handheld wireless devices that allow a student to access their learning environment anytime or anywhere (Baldwin & Ching, 2019; Chen et al., 2021; Kumar et al., 2022; Pebriantika et al., 2021; Voicu & Muntean, 2023). Previous research revealed that students were more inclined to use mobile technology to learn over other modalities such as a televised learning program (van Cappelle et al., 2021), were excited to learn, and felt that learning through a mobile device was effective (Jeong, 2022; Rifa'i & Sugiman, 2018; Salhab & Daher, 2023). Similarly, Liu, Wang et al. (2018) found that a mobile learning course specifically designed for smartphones showed significant improvements in post-score examinations for medical students in a medical training course.

Several studies have also focused on mobile device screen size and the levels of cognitive load a learner might experience (Alasmari, 2020; Dunaway & Soroka, 2021). There is some evidence that screen size affects the quality of the learner's experience (Alasmari, 2020; Dunaway & Soroka, 2021; Triyason & Krathu, 2017). Previous studies have shown that cognitive load increases as the screen size increases, showing that small screened (e.g., 4 inches) mobile devices such as smartphones are the best when being presented with information (Alasmari, 2020; Lee, Chiang, & Hsiao, 2021). Cabañero et al. (2019) found that consumption

tasks such as reading a message, listening to a podcast, and watching a video produced very little cognitive load. On the other hand, exploration tasks such as searching for information on a smartphone showed the highest cognitive load (Cabañero et al., 2019), which is why mobile device user interface research needs to be explored.

Mobile Device User Interface

The convenience and portability of mobile devices is what draws people to the device. However, due to size the user interface design of a mobile device provides usability challenges (Jahnke et al., 2020; Ofori & Lockee, 2021; Triyason & Krathu, 2017). Usability challenges involve things such as limitation of screen size (Li, 2020; Triyason & Krathu, 2017), touchscreen functionality (Enaya & Mohammed, 2020; Sutarno & Nugraha, 2017), dealing with cognitive overload (Alasmari, 2020; Cabañero et al., 2019), and distractions from the environment (Szita & Rooney, 2021). All these factors influence the learner's experience (Alasmari, 2020; Dunaway & Soroka, 2021; Triyason & Krathu, 2017).

This section of the literature review will cover: screen environment, screen environment distractions, and cognitive load and small screen devices.

Screen Environment

The portability of a mobile device is what draws people to them, but the small screen also provides limitations (Li, 2020; Sophonhiranrak, 2021; Triyason & Krathu, 2017). Due to the screen size, many things will not fit on one screen as it would on a laptop or desktop (Alasmari, 2020; Kabir & Kadage 2017; Li & Luximon, 2020) which can result in scrolling (Ohme et al., 2022; Sutarno & Kurniawan, 2017). Scrolling on a small screen can cause accidental touches that have led learners to a screen they did not recognize causing learners to become lost (Harte et al., 2018). Other challenges involve touch sensitivity (Enaya & Mohammed, 2020). For example, when a button is held for too long, a secondary function such as a menu may appear (Harte et al., 2018) or typing errors due to the size of the button (Sutarno & Nugraha, 2017). As a result of this, Li and Luximon (2020) found that learners avoided scrolling and button actions as much as possible in fear of making a mistake and tended to focus more on the content.

Other research (Li, 2020; Ohme et al., 2022; Park et al., 2018; Triyason & Krathu, 2017) found that screen size plays a major role in the effectiveness of displaying information. Park et

al. (2018) found that learners who used large screens scored higher on tests administered immediately after completing a mobile learning course. However, test scores decreased over time for learners who used a large screen while there was no significant difference in test scores for learners who took the mobile course on a small screen (Park et al., 2018). Conversely, Ohme et al. (2022) found significantly reduced learning on smartphones compared to desktops. In contrast, Dunaway and Soroka (2021) found high rates of recall across all screen sizes.

Screen Environment Distractions

The location of a learner can also influence their attention level. Research (Butler, 2018; Paas & Merriënboer, 2020; Puyana-Romero et al., 2022; Sewell et al., 2019; Zhang & Adipat, 2005) also suggests that nearby objects and environmental elements can affect cognitive load by inhibiting the learner's ability to process information. Contrary to this belief, Szita and Rooney (2021) found that screen size did not affect the proportion of time spent gazing at the screen while distractors were present. However, comprehension test scores were lower for learners who used a smartphone with distractors present (Szita & Rooney, 2021).

In contrast, other studies (Al-Furaih & Al-Awidi, 2021; Hartley et al., 2020; Zarandona et al., 2019) focused on the smartphone as a distraction while learning. Students reported that they used their smartphone for personal reasons such as making a call, answering text, sending an email, or checking social media while learning (Al-Furaih & Al-Awidi, 2021; Hartley et al., 2020; Zarandona et al., 2019). On the other hand, research found that students felt that the use of smartphones can be a distractor of the learning process (Al-Furaih & Al-Awidi, 2021; Alkhunzain, 2019), especially when distracted by other students using their smartphone while in class (Al-Furaih & Al-Awidi, 2021; Zarandona et al., 2019).

Cognitive Load and Small Screen Devices

Some research focused on the different stimuli that can affect a learners' mental effort in processing information while using a small screen device such as a smartphone (Al-Hunaiyyan et al., 2018; Cabañero et al., 2019). Mental effort refers to the amount of strain a learner exerts when undertaking a specific task (Cabañero et al., 2019; Curum & Khedo, 2021; McHugh & McCauley, 2020), and the total strain a learner undertakes is known as cognitive load (Cabañero et al., 2019; Curum & Khedo, 2021; Hwang et al., 2019; McHugh & McCauley, 2020). There are

three types of cognitive load: intrinsic, extraneous, and germane (Alasmari, 2020; Curum & Khedo, 2021; Faudzi et al., 2024; Paas & Sweller, 2014; Tan et al., 2020). Intrinsic cognitive load represents the inherent complexity of a task, extraneous cognitive load represents the distracting or irrelevant learning elements presented during the task, and germane cognitive load represents the mental effort devoted to constructing schemas that support understanding and recall (Alasmari, 2020; Curum & Khedo, 2021; Faudzi et al., 2024; Tan et al., 2020). Excessive cognitive load on a learner can yield negative effects on learning, performance, and motivation (Faudzi et al., 2024; Ohme et al., 2022; Refat et al., 2019; Young et al., 2021). Therefore, research has focused on limiting extraneous cognitive load by manipulating the way information is presented to improve learning accordingly (Alasmari, 2020; Hwang et al., 2019; Sweller et al., 2019).

Research has found that larger display screens are preferred because they can display more information and provide a higher quality experience (Alasmari, 2020; Ohme et al., 2022; Söderlund et al., 2019; Sutarno & Kurniawan, 2017; Triyason & Krathu, 2017). However, Alasmari (2020) found that students who experienced the lowest amount of extraneous cognitive load used small screen smartphones (e.g., 4 inches). This finding is attributed to small screens' ability to project small, chunked information (Alasmari, 2020). Other research found that organization of elements (Al-Hunaiyyan et al., 2018; Faudzi et al., 2024; Ohme et al., 2022), and design factors such as font size, background color, brightness, and contrast influences a learners' ease of learning and influences a learners' cognitive load (Faudzi et al., 2024; Lee et al. 2021; Ohme et al., 2022).

Message Design

Since instructors may not be readily available for assistance, care should be taken to consider the limitation of how screen space on a mobile device imposes challenges for the learner (Aljaber, 2021; Faudzi et al., 2024). The interface should follow learner friendly principles so that the learner can intuitively understand what is expected, but evidence-based mobile learning message design recommendations currently do not exist (Ofori & Lockee, 2021). Researchers (Alyahya & Nasser, 2019; Ofari & Lockee, 2021) have suggested that areas in

multimedia learning and instructional design could help support the design and planning of mobile learning on mobile devices.

This section of the literature review will cover: multimedia instructional messages, designing the message, and minimizing distractors in message design.

Multimedia Instructional Messages

There are many principles that are important for message design, which makes designing a challenge (Çeken & Taskin, 2022; Corbeil et al., 2023; Lohr, 2000; Wang & Shen, 2012). Researchers (Faudzi et al., 2024; Lohr, 2000; Ohme et al., 2022; Winn, 1993) suggested focusing on how message form and structural properties influence how the learner's mind recognizes information. According to the cognitive theory of multimedia learning, learners will retain more knowledge when words and pictures are presented together instead of separately (Almasseri & AlHojailan, 2019; Artman, 2020; Mayer, 2008; Mayer, 2021a; Mayer, 2021b; Mayer, 2024). Research has found that instruction designed with cognitive theory of multimedia learning principles significantly improved students' performance on post-test scores (Knoster, 2021; Mamiya Hernandez, 2020). Other studies had similar results but found no significant difference in scores between the experimental and control groups (Liu, Jang et al., 2018; Park, 2022).

The challenge for instructional message design is to avoid overloading the learner's cognitive capacity with extraneous information that could hinder the learner's cognitive process for learning (Almasseri & AlHojailan, 2019; Beukes, 2019; Mayer, 2008; Mayer, 2021a; Mayer, 2021b; Mayer, 2024). Mayer (2021a; 2021b; 2024) proposed 15 instructional methods intended to reduce extraneous processing, manage essential processing, and foster generative processing. To reduce extraneous processing, the reduction of elements that hinders the instructional objective, Mayer (2008; 2021a; 2021b; 2024) proposed five instructional methods: coherence, signaling, redundancy, spatial contiguity, and temporal contiguity. The second goal, managing essential processing focuses on helping the learner to focus on the learning objective, can be achieved by implementing three instructional methods: segmenting, pre-training, and modality (Mayer, 2008; 2021a; 2021b; 2024). The last goal of cognitive theory of multimedia learning focuses on generative processing, combining elements together to help the learner to learn new information through seven instructional methods: multimedia, personalization, voice, image, embodiment, immersion, and generative activity (Mayer 2008; 2021a; 2021b; 2024).

Much of the current research that incorporated Mayer's (2008; 2021a; 2021b; 2024) instructional methods into multimedia learning have shown varying results. Some studies found significant improvements in post achievement scores (Almasseri & AlHojailan, 2019; Knoster, 2021; Mamiya Hernandez, 2020; Setiyadi et al., 2019; Tin et al., 2018), whereas other studies found no significant improvement (Beukes, 2019; Liu, Jang et al., 2018; Park, 2022). Some researchers (Almasseri & AlHojailan, 2019; Mamiya Hernandez, 2020) found positive effects in learners' higher order thinking when multimedia learning instructional methods were implemented. Mamiya Hernandez (2020) found learners' accuracy increased in delayed posttest measures, and another study found a positive effect for higher order thinking skills (Almasseri & AlHojailan, 2019). Research has shown that the results of implementing Mayer's (2008; 2021a; 2021b; 2024) instructional methods into multimedia learning are varied. Just developing multimedia instruction does not automatically foster knowledge development, it also matters how elements are organized (Artman, 2020; Mayer, 2008; Mayer, 2021a; Mayer, 2021b, 2024).

Designing the Message

The design of an instructional message is considered an important form of communication that is used to improve a learner's performance (Alyahya & Nasser, 2019). An instructional message includes elements such as words, images, signs, and colors (Alyahya & Nasser, 2019; Mabachi et al., 2021; Sweller et al., 2019). The placement of elements, and the combination of multiple elements, influences the amount of cognitive load a learner experiences when processing information (Bashirzadeh et al., 2022; Ofori & Lockee, 2021; Sweller, 2020).

Aljaber (2021) emphasized the importance of how text is displayed. Scrolling text can impact information gathering and comprehension because the focal point might be on the movement rather than comprehension of the text (Harvey et al., 2019; Sanchez & Goolsbee, 2010; Støle et al., 2020). Similarly, Al-Samarraie et al. (2019) focused on a learner's eye movement, and found that students experienced significantly less cognitive load when reading text from a two-column layout versus a one-column and three-column layout. When text is paired appropriately with verbal instructions, Albus et al. (2021) found that learners who received verbal instructions and annotations, text that appeared to signal learners to focus on a visual entity, reached higher recall levels compared to those in the control group who did not learn with annotations.

An important element of a message is color (Alyahya & Nasser, 2019; Amarin & Al-Saleh, 2020). The use of color is important when designing instruction because the right color can facilitate learning (Alyahya & Nasser, 2019; Amarin & Al-Saleh, 2020; Güney, 2019; Rahmi & Azrul, 2021). Color can affect attention, search tasks, retention, and other measures (Alyahya & Nasser, 2019; Amarin & Al-Saleh, 2020; Güney, 2019) when paired with pertinent points in content (Ewoldt & Byrne, 2023; Pett & Wilson, 1996; Zwilling et al., 2020). Researchers (Alyahya & Nasser, 2019; Ofori & Lockee, 2021; Wang & Shen, 2012) suggested using color to distinguish between elements, focus on pertinent points, link related concepts, and utilize consistent colors to help reduce cognitive load. Alyahya and Nasser (2019) found that the use of color paired with an instructional infographic significantly influenced students' recall of information.

Minimizing Distractors in Message Design

More recently, researchers have focused on the effects of extraneous cognitive load on learning objectives, specifically on elements that do not contribute to learning (Albus et al., 2021; Beege et al., 2020; Eitel et al., 2019; Sentz et al., 2019; Skulmowski & Xu, 2021). Extraneous cognitive load elements that do not contribute directly to learning are considered distractions or inadequate instructional design (Albus et al., 2021; Sentz et al., 2019; Skulmowski & Xu, 2021; Sweller, 2020). Eitel et al. (2019) found that students who were not guided on how to distinguish between distractions and relevant information performed worse than the control group and the informed group. Similarly, Beege et al. (2020) found that learners who received signaled text outperformed learners who did not receive signaled text, but text disfluency had no influence on learning outcomes.

Other research focused on distractors in layout and graphics (Alebri et al., 2024; ĩlic & Akbulut, 2019; Rop et al., 2018). Rop et al. (2018) found there were no significant differences in learning between different diagram layouts that included distractors. Similarly, ĩlic & Akbulut (2019) found no significant difference in learning outcomes in the experimental group when disfluency was applied to text and animations. However, learners in the experimental group experienced a significant difference in extraneous cognitive load if material appeared more difficult or unusual (ĩlic & Akbulut, 2019; Rop et al., 2018). Consistent to Beege et al. (2020), Albus et al. (2021) found that learners who learned in a virtual reality environment and

experienced learning with annotations scored higher in recall performance than learners who did not receive annotations.

Microlearning

Microlearning is an emerging practice in various fields of workplace training (Corbeil et al., 2021; Lee et al., 2021b), yet limited academic research exists (Dolasinski & Reynolds, 2020). The popularity of microlearning in workplace training arose due to the need for just-in-time training that is accessible from anywhere (Hogle, 2021; Inker et al., 2021; Lee et al., 2021b). Research has shown that microlearning-designed workplace training facilitated knowledge acquisition by motivating employees to apply what they learned (Inker et al., 2021; Leong et al., 2021). This approach can also be used as a framework for designing mobile learning.

This section of the literature review will cover: what is microlearning, mobile microlearning, and mobile microlearning guiding principles.

What is Microlearning?

Microlearning has become a popular strategy to help learners grasp content (De Gagne et al., 2019; Leong et al., 2021), decrease the cognitive load when learning new concepts (De Gagne et al., 2019; Shail, 2019; Wang et al., 2021), and improve retention (Diaz Redondo et al., 2020; Ichiuji et al., 2021; Shail, 2019). Microlearning is very short, bite sized, just-in-time lessons that can be consumed quickly (Alqarni, 2021; Jahnke et al., 2020; Torgerson & Iannone, 2020), can be stand alone, or used as a supportive learning activity (Torgerson & Iannone, 2020). There are four common ways to use microlearning (Torgerson & Iannone, 2020): (a) preparation before a learning event; (b) follow-up to support a learning event; (c) standalone training; and (d) performance support. Although the term microlearning has not been standardized (De Gagne et al., 2019; Torgerson, 2021), the common feature of microlearning is that it is brief and enables learners to focus on one piece of information at a time (Alqarni, 2021; De Gagne et al., 2019; Leong et al., 2021; Shail, 2019).

Some research says that microlearning should be about 30 seconds to 90 seconds (Jahnke et al., 2020), while Hug (2007) suggested lessons should not exceed five minutes in length. However, Torgerson and Iannone (2020) found that the length is determined on how you will use microlearning. Depending on the type of support, a microlearning resource may need to be 30

seconds or less (Jahnke et al., 2020), one minute (De Gagne et al., 2019), 5-9 minutes (Diaz Redondo et al., 2020; Wang et al., 2021), or 10 minutes (Torgerson & Iannone, 2020). But a microlearning resource should not exceed 15 minutes (De Gagne et al., 2019; Diaz Redondo et al., 2020; Leong et al., 2021). If learning is not required, a learner will gravitate to resources that are four minutes or less (Diaz Redondo et al., 2020; Kapp & Defelice, 2019; Torgerson & Iannone, 2020). If learning is required, researchers (Diaz Redondo et al., 2020; Torgerson & Iannone, 2020; Wang et al., 2021) found that five to nine minutes is necessary to effectively teach a concept and capture students' attention. For the purpose of this study, microlearning is defined as learning content focused on a single learning objective (Alqarni, 2021; De Gagne et al., 2019; Leong et al., 2021; Shail, 2019) that can be consumed in 15 minutes or less (De Gagne et al., 2019; Diaz Redondo et al., 2020; Leong et al., 2021).

Although microlearning appeared in a variety of research areas, researchers have used a variety of microlearning modalities, including: (a) text-based resources (Diaz Redondo et al., 2020; Lee et al., 2021b; Torgerson & Iannone, 2020); (b) videos (Jahnke et al., 2020; S. Heydari et al., 2019; Lee et al., 2021b; Lee-Fiedler, 2021; Nikou & Economides, 2018b; Torgerson & Iannone, 2020; Wang et al., 2021); (c) audio or screen recording (Lee et al., 2021b; Jahnke et al., 2020; Wang et al., 2021); (d) podcasts (De Gagne et al., 2019; Diaz Redondo et al., 2020; Heydari et al., 2019; Lee-Fiedler, 2021; Nikou & Economides, 2018b; Torgerson & Iannone, 2020); and (e) presentations (Jahnke et al., 2020; Wang et al., 2021). However, videos have become the most popular microlearning format (Hanshaw & Hanson, 2018; Wang et al., 2021) because research has shown that video education is an effective method that can be used to demonstrate concepts, techniques, and procedures (Abu Farha et al., 2020; Lambert et al., 2018; Ou et al., 2019). Past video education research demonstrated significant improvements in test scores (Abu Farha et al., 2020; Yuda Handaya et al., 2021), better retention (Alqarni, 2021; Gross et al., 2019), and high levels of student satisfaction (Abu Farha et al., 2020; Gross et al., 2019; Ou et al., 2019; Shalawati et al., 2022; Valls Martínez et al., 2021).

Mobile Microlearning

Mobile learning combined with microlearning focuses on the mobility and flexibility of learning anytime and anywhere on a small portable screen device (Diaz Redondo et al., 2020; Hanshaw & Hanson, 2018; Lee et al., 2021b; Shail, 2019). Learning is informal and allows the

learner to have the ability to learn while walking to their next destination, or while riding the bus (Grant, 2019; Lee et al., 2021b; Wang et al., 2021). Although this is general for all types of mobile learning, combining mobile learning and microlearning can offer support to the learner in a different way (Hanshaw & Hanson, 2018; Lee et al., 2021b; Shail, 2019).

The term mobile microlearning has evolved into an emergent practice for corporate and workplace training (Clark et al., 2018; Jahnke et al., 2020) to accommodate the busy schedules of employees (Hanshaw & Hanson, 2018; Stratton et al., 2020). Previous research has established that participants liked the accessibility of the microlearning training on a mobile device (Hall, 2021; Heydari et al., 2019), having the ability to repeatedly watch videos (Wang et al., 2021; Zheng, 2021), and favored the format because training time was reduced (Hall, 2021). Much of the current literature also found improved learner motivation (Alqarni, 2021; Lee, 2021a; Nikou & Economides, 2018b), knowledge retention (Alqarni, 2021; Boring, 2020; Lee, 2021a, Lee et al., 2021b), and performance (Alqarni, 2021; Boring, 2020; Lee, 2021a; Lee et al., 2021b; Mohammed et al., 2018; Wang et al., 2021). Similarly, Lee et al. (2021b) found that 80% of learners in a journalist training course obtained higher scores after completing the microlearning course. Conversely, Skalka and Drlik (2020) reported no significant improvement in student results in advanced topics of an introductory programming course despite the positive perception of the microlearning units by the students. At the same time, Sankaranarayanan (2022) found a significantly higher difference in scores for students who learned with microlearning-designed instruction, and Alqarni (2021) reported that secondary school students learned significantly more programming skills with microlearning videos.

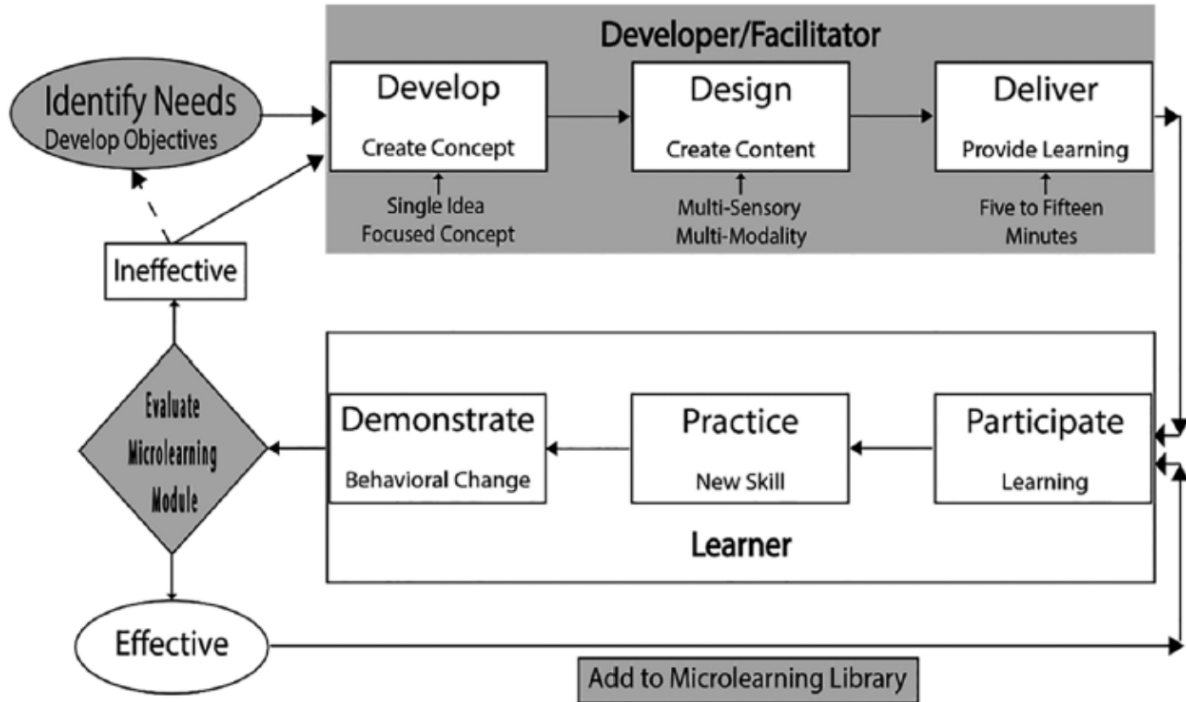
Mobile Microlearning Guiding Principles

Similar to mobile learning, mobile microlearning does not adhere to a set of design principles, resulting in varied design guidelines in microlearning research (Jahnke et al., 2020; Lee et al., 2021b). Dolasinski and Reynolds (2020) proposed a microlearning model based on previous research in learning and tested learning theories that also incorporate aspects of models such as ADDIE. As shown in Figure 1, the microlearning model consists of four phases that reflect essential elements of microlearning (Dolasinski & Reynolds, 2020): (1) identify needs and develop learning objectives; (2) development, design, and delivery of learning concept and content; (3) participating, practice, and demonstration; and (4) evaluate learning content. The

first phase of the Dolasinski and Reynolds's (2020) microlearning model involves identifying the specific training need and developing learning objectives that will help to accomplish the training need. The second phase of the model is guided by the learning objectives from the first phase to develop, design, and deliver the learning content. Specific to microlearning, these steps involve narrowing the learning content to focus on one single idea, one single learning objective (De Gagne et al., 2019; Dolasinski & Reynolds, 2020; Dolasinski & Reynolds, 2021; Jahnke et al., 2020; Leong et al., 2021; Shail, 2019). If a learning objective has several concepts, each concept is a separate learning module (Dolasinski & Reynolds, 2020; Dolasinski & Reynolds, 2021; Jahnke et al., 2020). Microlearning design utilizes multimodality elements to provide support to all types of learners to understand and retain learning (Dolasinski & Reynolds, 2020; Dolasinski & Reynolds, 2021; Jahnke et al., 2020). Although research has not identified a standardized delivery length for learning, current practices of microlearning suggests 5 minutes to 15 minutes (De Gagne et al., 2019; Diaz Redondo et al., 2020; Dolasinski & Reynolds, 2020; Hug, 2007; Jahnke et al., 2020; Leong et al., 2021). Overall, the second phase of the microlearning model is similar to ADDIE's design and development stages combined, except the microlearning model has a delivery element that focuses on length of the learning. Phase 3 involves the learner's participating, practicing, and demonstrating the accomplished learning objective (Dolasinski & Reynolds, 2020; Dolasinski & Reynolds, 2021). The last phase, evaluating the microlearning module, focuses on assessing the effectiveness of the learning module design by obtaining performance results, feedback from learners, and observations from facilitators or learners regarding behavior changes (Dolasinski & Reynolds, 2020; Dolasinski & Reynolds, 2021). Results from hospitality training and education classes suggested that students learned from the microlearning model designed learning, and learners found the microlearning style of lessons favorable (Dolasinski & Reynolds, 2021; Reynolds & Dolasinski, 2020).

Figure 1

Microlearning Model



Note. Reprinted from *Microlearning: A new learning model*, by M. J. Dolasinski and J. Reynolds, 2020. *Journal of Hospitality & Tourism Research (Washington, D.C.)*, 44(3), 551–561.

Other researchers (Jahnke et al., 2020; Lee et al., 2021b; Tufan, 2021) applied instructional design principles as a guide for their proposed models. Tufan (2021) emphasized the importance of managing cognitive processing in the instructional design of microlearning and suggested using Mayer’s Principles of Multimedia Learning (2008; 2021a; 2021b; 2024) to help guide design decisions for microlearning. In other research (Jahnke et al., 2020; Lee et al., 2021b), Gagné’s Nine Events of Instruction (1992) was identified as the underlying design principles for a Four Instructional Flow of microlearning lessons. Jahnke et al. (2020) lists the Four Instructional Flow that should be built into microlearning: (1) cues to showcase relevance of topic; (2) interactive content; (3) short exercises to apply learned content; and (4) instant

feedback. The first step involves capturing the learner's attention from the start of the lesson (Gagné et al., 1992; Jahnke et al., 2020; McHugh & McCauley, 2020) through cues that focus the learner's attention to the single learning objective (Jahnke et al., 2020). The second step suggests incorporating interactive content that allows students to practice what they just learned (Jahnke et al., 2020; Ou et al., 2019). The third step aims to identify learner gaps by engaging the learner in quizzes or gamified activities (Jahnke et al., 2020). The last step focuses on providing learners with immediate feedback to allow learners to promptly correct errors (Jahnke et al., 2020). Research indicates that immediate feedback has a significant impact on learning (Naseem et al., 2022; Wisniewski et al., 2020) and is preferred by students (Ou et al., 2019) because immediate feedback allows students to make informed decisions about their learning strategies (Carless & Boud, 2018; Hooshyar et al., 2020). While there are few studies that explored the implementation of Jahnke et al.'s (2020) Four Instructional Flow, existing research findings are positive. Results gathered from a mobile microlearning journalism course revealed that 80% of learners significantly improved their posttest scores after completing lessons designed with Jahnke et al.'s (2020) Four Instructional Flow (Lee et al., 2021b). The mobile microlearning lessons also appealed to most of the learners because the short lessons conveniently fit into their daily routines (Lee et al., 2021b).

Conceptual Framework

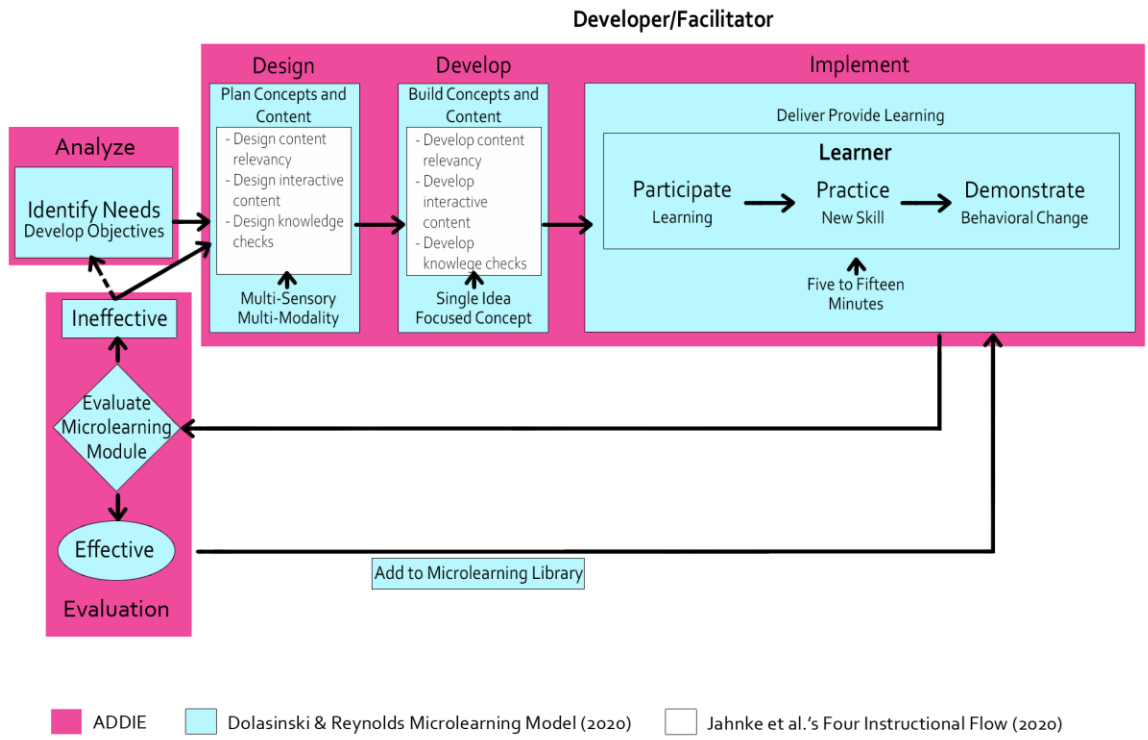
The theoretical perspectives for mobile learning cover various backgrounds, particularly for instructional design and learning on mobile devices such as laptops or tablets. Since there is limited research on microlearning design frameworks (Zhang & West, 2020), ADDIE, a commonly used model in the instructional design field (Budoya et al., 2019; Yeh & Tseng, 2019) will be used as the foundation of this study's conceptual framework, and elements from Dolasinski and Reynolds's (2020) Microlearning Model, and Jahnke's et al.'s (2020) Four Instructional Flow model are incorporated into the proposed Designing for One - Microlearning Design & Development (DO-MDD) Framework shown in Figure 2. To maintain consistency with ADDIE, the Microlearning Model's Develop and Design phases (Dolasinski & Reynolds, 2020) were flipped to align with ADDIE's instructional design framework. ADDIE is a popular instructional design model that has been applied in a variety of research disciplines (Stefaniak &

Xu, 2020) such as K-12 education (Budoya et al., 2019; Samur, 2018; Shalawati et al., 2022), higher education (İneç & Akpınar, 2018; Lim & Burton, 2021; Misesani et al., 2020), and training (Trust & Pektas, 2018; Yeh & Tseng, 2019; Yu et al., 2021).

The ADDIE model contains five phases: analysis, design, development, implementation, and evaluation. The analysis phase examines standards and determines the instructional objectives of the lesson (Budoya et al., 2019; Hanafi et al., 2020; Lafleur et al., 2021; Shalawati et al., 2022; Yeh & Tseng, 2019). The design phase identifies instructional activities, materials, and assessment methods to help the learner to achieve instructional objectives that were identified in the analysis phase (Budoya et al., 2019; Hanafi et al., 2020; Lafleur et al., 2021; Shalawati et al., 2022; Yeh & Tseng, 2019). The development phase utilizes elements identified in the design phase to create the lesson (Budoya et al., 2019; Hanafi et al., 2020; Lafleur et al., 2021; Shalawati et al., 2022; Yeh & Tseng, 2019). The implementation phase delivers the lesson to the learners (Budoya et al., 2019; Hanafi et al., 2020; Lafleur et al., 2021; Shalawati et al., 2022; Yeh & Tseng, 2019). The evaluation phase assesses the effectiveness of the developed lesson by identifying whether instructional objectives are met or if gaps exist (Budoya et al., 2019; Hanafi et al., 2020; Lafleur et al., 2021; Shalawati et al., 2022; Yeh & Tseng, 2019). It should be noted that the ADDIE model is not linear (Artman, 2020; McHugh & McCauley, 2020). Designers can transition through different phases to allow for corrective measures at any stage (Artman, 2020; McHugh & McCauley, 2020).

Figure 2

Designing for One - Microlearning Design & Development (DO-MDD) Framework



■ ADDIE
 ■ Dolasinski & Reynolds Microlearning Model (2020)
 Jahnke et al.'s Four Instructional Flow (2020)

Note: Integrated microlearning design framework based on ADDIE, Dolasinski and Reynolds's (2020) Microlearning Model, and Jahnke's et al.'s (2020) Four Instructional Flow.

The goal of the proposed DO-MDD framework is to guide instructors through clearly defined stages when independently designing microlearning. To provide specific microlearning design guidelines for mobile learning, the Microlearning Model (Dolasinski & Reynolds, 2020) and the Four Instructional Flow model (Jahnke et al., 2020), as shown in Figure 2, were used as the guiding principles for designing microlearning on mobile devices.

Microlearning is an emerging practice (Corbeil et al., 2021; Lee et al., 2021b) that can be applied as a framework for designing mobile learning on small screen devices (Diaz Redondo et al., 2020; Hanshaw & Hanson, 2018; Lee et al., 2021b; Shail, 2019). The DO-MDD Framework

has the potential to provide new insights into the design and pedagogy of mobile learning designed interventions and requires evaluation to determine the impact a microlearning-designed intervention has on academic achievement. To assess the impact of the microlearning-designed intervention, acquisition of content knowledge and willingness to learn were assessed using student performance data shared by instructors, which reflected performance aligned with their own course learning outcomes. Assignments and quizzes were utilized to evaluate understanding and retention, while John Keller's (2010) Instructional Methods Motivational Survey (IMMS) guided the development of the online student survey. The IMMS questions served as the quantitative component of the online student survey, used to evaluate the effectiveness of the microlearning interventions by examining students' willingness to learn (Chang et al., 2019; Tsai et al., 2022) based on their learning experiences. Traditionally, the IMMS instrument (Keller, 2010) is used to measure student motivation and behavior (Tsai et al., 2022), assessing instructional strategies through the elements of the ARCS model of motivation (Keller, 2010): attention, relevance, confidence, and satisfaction.

For the purpose of this study, the IMMS survey was adapted to explore students' likelihood of continued use and preference for learning programming with the DO-MDD designed microlearning video lessons. While grounded in the ARCS model (Keller, 2010), the survey items were used as indicators of how the instructional design impacted students' engagement and sustained interest in the microlearning format. Research (Li & Keller, 2018; Lo et al., 2022; Mohamed Yunus & Paimin, 2019; Tsai et al., 2022) has shown that incorporating motivational elements into instructional materials are strongly linked to students' academic success and continued engagement in learning. Specifically, the IMMS survey was employed to evaluate learner engagement by assessing elements of Keller's (2010) ARCS model.

Overall, this proposed conceptual framework can help to contribute to research in the field of mobile learning. The DO-MDD framework can help to provide a way to apply a consistent framework when designing mobile learning.

Summary

Technological advancements, improved accessibility, and the increasing demand for instant information have all contributed to the growing use of mobile devices in education.

Although academic literature has explored various practices for designing mobile learning, there are still established design principles specifically for designing mobile learning. However, research suggests that mobile microlearning design elements can potentially fill this gap. This study contributes to this area of research by proposing a conceptual framework aimed at providing clear guidelines for designing mobile learning lessons using microlearning principles. This next chapter will describe the research design and methodology that addressed the five research questions that guided this study.

CHAPTER 3. METHODOLOGY

This case study aimed to examine the Designing for One - Microlearning Design & Development (DO-MDD) framework as an applicable framework for designing mobile learning through understanding higher education instructors' experiences with using the DO-MDD framework. Instructors created microlearning video lessons using the DO-MDD framework to teach an entire programming module or a specific activity within the module. This study also examined student perceptions of learning with video lessons created with the DO-MDD framework. To address the research questions, three instructors in higher education who designed lessons using the DO-MDD framework were studied. Within the setting, the study also collected data from the instructors' students who learned from lessons designed with the DO-MDD framework. In this study, instructor self-reflective journals, instructor interviews, student interviews, open-ended questions from the online student survey, and researcher video observations provided qualitative data, while student learning data, specifically assignment and quiz scores when available, student behavior data obtained from YouTube Analytics, and IMMS question data from the online student survey generated the quantitative data. The rationale behind the research design is twofold. First, qualitative data focused on understanding the learning effects and perceptions of microlearning video lessons designed for mobile learning with the DO-MDD framework. Qualitative data were also used to understand the instructors' experiences with the proposed model when they designed and implemented programming lessons designed with the DO-MDD framework. Second, qualitative and quantitative data were used to capture students' learning experiences when they learned with the programming lessons designed with the DO-MDD framework. The rationale for collecting both qualitative and quantitative data was to provide a more in-depth interpretation of the data that cannot be obtained with a single method study (Creswell, 2022; Creswell & Creswell, 2018; Poth, 2018).

This chapter will review the research questions and describe the research methodology, including the conceptual framework, participants, setting, role of the researcher, data collection, data analysis, validity, and the timeline.

Research Questions

This study had two main focuses. This study focused on collecting data from higher education instructors who designed lessons with the DO-MDD framework and collected data on student experiences. More specifically, the first focus of this study was to capture the instructors' experiences by collecting data on their use of the DO-MDD framework, their perceptions of the proposed framework, and the instructors' perceptions of students' learning using the microlearning programming video lessons created with the DO-MDD framework. These observations were informed by instructor-reported insights, including student feedback and, if results were available, performance data such as quiz or assignment scores. Furthermore, this study also captured student experiences by collecting data on student perceptions of the lessons designed with the proposed framework and collected data on the effects of the programming video lessons designed with the DO-MDD framework on student learning. Based on this understanding, there are five research questions that guided this study:

1. How did the instructors use the DO-MDD framework?
2. What are the instructors' perceptions of the DO-MDD framework?
3. What are the instructors' perceptions of students' learning using the lessons designed based on the DO-MDD framework?
4. What are students' perceptions of lessons based on the DO-MDD framework?
5. How do lessons based on the DO-MDD framework hinder/enhance student learning?

Research Design

A case study approach was adopted because the scope of this study called for collecting multiple sources of data to provide an in-depth description of a case (Thomas, 2021; Johnson & Christensen, 2020; Yin, 2018). This study aimed to explore the possible impact of lessons designed using the DO-MDD framework by examining higher education instructors' perceptions of its design and application, as well as student perceptions of learning from lessons created with the framework. To achieve this, two different data collection methods were employed. The first method focused on collecting qualitative data to reveal a holistic view of the experience to reveal a larger picture of what emerged (Johnson & Christensen, 2020; Creswell & Creswell, 2018).

The second method involved collecting quantitative data to obtain additional insights that could not be obtained through qualitative data alone (Creswell & Creswell, 2018). Table 2 below outlined the relationship between the research questions and instrument data type that was used for this study. This combination of quantitative and qualitative methods reflected a customized approach, a typical characteristic of a case study (Yin, 2018).

Table 2

Alignment of Research Questions with Instrumentation and Data Type

Research Questions	Journals (QUAL)	Interviews (QUAL)	Researcher Video Observations (QUAL)	Online Questionnaire (QUAL & QUANT)	Student Learning (QUANT)	Student Behavior (QUANT)
1. How did the instructor use the DO-MDD framework?	Self-reflective instructor journal	Semi-structured instructor interview	n/a	n/a	n/a	n/a
2. What are the instructor's perceptions of the DO-MDD framework?	Self-reflective instructor journal	Semi-structured instructor interview	Selected YouTube videos	n/a	n/a	n/a
3. What are the instructor's perceptions of students' learning using the lessons designed based on the DO-MDD framework?	Self-reflective instructor journal	Semi-structured instructor interview	n/a	n/a	Results from quizzes and assignments	n/a
4. What are students' perceptions of lessons based on the DO-MDD framework?	n/a	Semi-structured student interviews	n/a	Questions 1-36 (QUANT); Question 39 (QUAL)	n/a	n/a

Research Questions	Journals (QUAL)	Interviews (QUAL)	Researcher Video Observations (QUAL)	Online Questionnaire (QUAL & QUANT)	Student Learning (QUANT)	Student Behavior (QUANT)
5. How do lessons based on the DO-MDD framework hinder/enhance student learning?	Self-reflective instructor journal	Semi-structured instructor interviews; semi-structured student interviews	n/a	Questions 1-36 (QUANT); Questions 37 and 38 (QUAL)	Results from quizzes and assignments	YouTube Analytics

The first data collection method focused on collecting and analyzing qualitative data to explore the perspectives and behaviors (Creswell & Creswell, 2018) of the instructors and students regarding the DO-MDD framework. This method involved collecting various types of qualitative data: (a) instructors’ self-reflective journals, (b) instructor semi-structured interviews, (c) student semi-structured interviews, and (d) open-ended questions from the online student questionnaire. In addition, the researcher conducted an observational review of selected instructor-created video lessons to contextualize how the framework was applied in practice. This variety of qualitative data collection helped to explore the individual experiences (Flick, 2020) of the instructors as they applied the DO-MDD framework in designing and implementing microlearning video lessons, and the students’ learning experiences with the microlearning video lessons created with the DO-MDD framework.

In addition to collecting qualitative data about the instructors’ and students’ experiences, quantitative data were collected. This second method included the following: (a) online student questionnaire, (b) student learning data, and (c) student behavior data. Quantitative data from the online student questionnaire were obtained from the IMMS questions 1-36. The quantitative data helped to provide multiple layers that provided a more well-rounded understanding of the themes embedded in the data (Watkins, 2023; Van Haneghan, 2021).

Given the diversity of the data collected, a case study approach was deemed the most effective approach to investigate the DO-MDD framework (Thomas, 2021; Johnson & Christensen, 2020; Yin, 2018). This approach allowed for a holistic (Johnson & Christensen, 2020; Creswell & Creswell, 2018) exploration of the DO-MDD framework by investigating the

experiences of the higher education instructors and their students. By examining the experiences of multiple participants, the case study approach provided a rich and detailed description (Gast & Ledford, 2024) of the framework's effectiveness for mobile learning.

Conceptual Framework

The DO-MDD framework serves as the conceptual framework for this study, which guided the design and implementation of mobile microlearning lessons for higher education programming courses. While a variety of design principles exist to create mobile learning lessons, there is limited research that focuses on designing learning in a microlearning format (Zhang & West, 2020). To address this gap, the DO-MDD conceptual framework was created for this study, using the ADDIE framework as the foundation of the conceptual framework and incorporated elements from Dolasinski and Reynolds's (2020) Microlearning Model, and Jahnke et al.'s (2020) Four Instructional Flow model as shown in Figure 2.

The DO-MDD framework was not only developed to address the gap in established mobile learning design principles but also to provide instructors with a clear process for creating mobile microlearning lessons. By incorporating Dolasinski and Reynolds's (2020) Microlearning Model, and Jahnke et al.'s (2020) Four Instructional Flow model into the ADDIE framework, the DO-MDD framework was predicted to offer instructors a clear and structured framework that could be followed with ease. To align with ADDIE, the Develop and Design phases of the Microlearning Model (Dolasinski & Reynolds, 2020) were flipped to stay aligned with ADDIE's instructional design process.

The DO-MDD framework was designed with the expectation that instructors would be able to independently create mobile microlearning lessons that align with microlearning principles. By following the framework's process, instructors were expected to create lessons that enhanced engagement and improved learning outcomes. To assess the effectiveness of the DO-MDD framework, a comprehensive analysis of the instructors' and students' experiences would provide insight into the framework's impact.

Participants and Context

The effectiveness of the DO-MDD framework was conducted in a variety of higher education settings. To provide a clear understanding of the study's context, the following sections describe the study's setting and participants who participated. These details help to provide context for how the DO-MDD framework was applied in educational settings and how data were collected from the participants.

Study Setting

This study was conducted in online, hybrid, and face-to-face programming courses for first- and second-year college students at two different colleges in Hawai'i. The delivery of the DO-MDD designed microlearning video lessons occurred through the college institutions' learning management system. Since each instructor created their own unique set of microlearning videos that were implemented at different parts of the semester, qualitative and quantitative data were collected throughout different times during the duration of the study. Student learning data collected from assignments and quizzes occurred from the day of implementation until the last item was due. Data collection began in Spring 2023 and ended in Fall 2023.

Participants

The target population for this study was higher education programming instructors and their students in their first and second year of college. Three instructors were recruited based on their interest in designing microlearning-designed lessons. Previous research has shown mixed results regarding the effectiveness of microlearning as a design and development method for creating microlearning lessons for advanced topics such as programming (Sankaranarayanan, 2022; Skalka & Drlik, 2020). Each instructor created their own mobile microlearning video lessons for specific aspects of their programming course. Video lessons were used as the chosen format due to videos being the most popular microlearning format (Hanshaw & Hanson, 2018; Wang et al., 2021). Research has shown that video lessons are an effective method to demonstrate concepts, techniques, and procedures (Abu Farha et al., 2020; Lambert et al., 2018). Each instructor participated in at least one setup meeting, a semi-structured interview after the semester was completed, a member check interview, and a self-reflective journal for each

semester where their microlearning videos were implemented. Additionally, one instructor granted full access to their microlearning videos designed with the DO-MDD framework. The researcher reviewed a selection of these videos to provide additional insights into how the framework was applied and to support interpretation of instructor and student-reported experiences.

To ensure consistency in the implementation of the framework, instructors were onboarded individually through an initial Zoom meeting that provided an overview of the study's purpose, expectations, and the DO-MDD framework. During this session, the researcher walked each instructor through the framework step-by-step and encouraged them to ask questions. A follow-up check-in was conducted through Zoom or email prior to the construction of the microlearning video lessons. Ongoing support was offered throughout the semester through email, text, and Zoom, allowing instructors to clarify questions or share feedback during the entire process.

This study required the collection of both qualitative and quantitative data from students. To facilitate this, instructors notified students in their programming courses about an opportunity to participate in the study. The message informed students that those who participated in the online questionnaire would have the option to obtain a \$5 Amazon eGift card, and those who participated in a semi-structured interview could obtain a \$10 Amazon eGift card at the completion of the study. The eGift card incentives were intended to increase participation rates (Abdelazeem et al., 2023; Jia et al., 2021; Sataloff & Vontela, 2021; Stanley et al., 2020), compensate students for their time, and obtain a more representative sample of student perspectives. There was a total of 38 students who participated in the online student questionnaire. Informed consent was obtained electronically before students could access the questionnaire. Among the 38 students who participated in the online student questionnaire, six students participated in a semi-structured interview. Of the six students who participated in a semi-structured interview, five students participated in a member check interview.

Role of the Researcher

The researcher's role was to provide insights into the perceived usefulness of the DO-MDD framework for designing microlearning videos to support mobile learning in higher

education. The goal was to conduct the study and report findings in a non-biased manner. The researcher, with 13.5 years of experience as a former college instructor who has designed and taught face-to-face, online (synchronous and asynchronous), and hybrid settings, has also spent the past four years working as an educational technologist. In this role, she has provided technical and pedagogical support to instructional faculty in designing, developing, delivering, and evaluating classes, creating instructional material, and assisting in assessing and determining the most appropriate interactive technology for instructional engagement. While these experiences have given her valuable insights into this topic, the researcher's main interests have been about exploring the mobile microlearning experiences of instructors and students.

During this study the researcher provided guidance to instructors through setup meetings and email communication as they developed mobile microlearning lessons for their programming courses. As the student participants were part of the instructors' courses, the researcher remained unfamiliar to all students who participated in this study. In addition, the researcher conducted an observational review of selected microlearning video lessons to further contextualize the application of the DO-MDD framework in practice and to support the interpretation of reported experiences. Despite this, the researcher acknowledged potential biases due to her past experiences. Strategies to ensure rigor in this case study and to control bias will be discussed further in Chapter 3.

Instrumentation and Procedures

This study analyzed both qualitative and quantitative data collected to answer the research questions. Qualitative data, which served as the primary data set, was collected through semi-structured interviews, self-reflective journals, open-ended questions from the online student questionnaire, and researcher video observations. Quantitative data, which supported and complemented the qualitative findings, was collected through the IMMS questions in the online student questionnaire, student learning data, and student behavior data. Table 3 below outlined the relationship between the research questions, instruments, and instrument protocols that were used for this study.

Table 3*Alignment of Research Questions with Instrumentation and Protocol*

Research Question	Instrument	Protocol
1. How did the instructor use the DO-MDD framework?	Instructor reflective journal; instructor interview	Instructor provided 9 prompts for journal; semi-structured instructor interview protocol (See Appendix A)
2. What are the instructor's perceptions of the DO-MDD framework?	Instructor reflective journal; instructor interview; researcher video observations	Instructor provided 9 prompts for journal; semi-structured instructor interview protocol (See Appendix A); researcher reviewed selected videos for alignment with DO-MDD framework (See Appendix F)
3. What are the instructor's perceptions of students' learning using the lessons designed based on the DO-MDD framework?	Instructor reflective journal; instructor interview; student learning data	Instructor provided 9 prompts for journal; semi-structured instructor interview protocol (See Appendix A); instructor-reported assignments and quiz results ^a (from reflections and interviews)
4. What are students' perceptions of lessons based on the DO-MDD framework?	Student interviews; student questionnaire	Semi-structured student interview protocol (See Appendix C); online student questionnaire has 40 items (See Appendix B)
5. How do lessons based on the DO-MDD framework hinder/enhance student learning?	Instructor reflective journal; instructor interview; student questionnaire; student interviews; student learning data; student behavior data	Instructor provided 9 prompts for journal; semi-structured instructor interview protocol (See Appendix A); online student questionnaire has 40 items (See Appendix B); semi-structured student interview protocol (See Appendix C); instructor-reported assignments and quiz results ^a (from reflections and interviews); student behavior data collected from YouTube Analytics

^aData were aggregated and not linked to individual students.

Instructors created microlearning video lessons using the DO-MDD framework to teach an entire programming module or a specific activity within the module. For this study, microlearning is defined as learning content focused on a single learning objective (Alqarni, 2021; De Gagne et al., 2019; Leong et al., 2021; Shail, 2019) that can be consumed in 15 minutes or less (De Gagne et al., 2019; Diaz Redondo et al., 2020; Leong et al., 2021). While the recommended length for each microlearning video lesson was 15 minutes, instructors were informed that they had the flexibility to adjust the duration. However, the core principles of microlearning had to be upheld, ensuring content remained shorter than a typical full-length lesson of an hour or more. To assess the effectiveness of the DO-MDD framework in designing microlearning video lessons, the study employed qualitative and quantitative instruments to gather insights from the experiences of the instructors and students.

Qualitative Instruments

To gain a rich in-depth understanding of the instructors' experiences with designing and implementing mobile microlearning-designed videos, self-reflective journals, semi-structured interviews, and researcher video observations were conducted. The self-reflective instructor journals helped to seek depth, and detail of the instructors' experiences (Billups, 2019) with designing and implementing microlearning-designed lessons using the DO-MDD framework. The instructors were expected to complete a self-reflective write-up after the construction of the microlearning videos, and after each completed programming unit or activity. By the end of each completed unit or activity, students completed an assignment and or quiz. The instructors were given nine prompts aimed at helping them to focus their reflections (Billups, 2019) on the design and implementation phases of the DO-MDD framework:

1. How was the DO-MDD framework applied during the development of the microlearning lessons?
2. What are some of the challenges that you experienced with designing and implementing microlearning lessons?
3. What are some of the benefits that you experienced/witnessed while designing and implementing microlearning lessons?
4. Were there areas where you received more or less questions than in past classes during the same unit?

5. What are some challenges that your students seemed to experience with the microlearning lessons?
6. What are some successes that your students seemed to experience with the microlearning lessons?
7. What is your assessment of your students learning with the microlearning lessons? Your assessment can be based on graded results from student behavior data (YouTube Analytics), homework, tests, or quizzes, and can also include communication with students.
8. Were there any behavior changes in your students after learning with the microlearning lessons?
9. Is there anything else you would like to share about your experience with designing and implementing microlearning lessons?

A semi-structured interview protocol was created and used as a guide to conduct follow-up Zoom interviews to the instructors' self-reflective journals. See Appendix A for a complete interview protocol for the instructor interview. There are six main questions in the instructor interview protocol to help obtain a deeper understanding of the instructors' experiences with the DO-MDD framework:

1. How did the DO-MDD framework guide in the development of microlearning lessons?
 - a. How was the process of getting started with the DO-MDD framework?
 - b. What are your perceptions of using the DO-MDD framework?
 - c. Were there specific aspects of the framework that were difficult to integrate into the design and development of the microlearning videos?
 - d. Were there specific aspects of the framework that were easy to integrate into the design and development of the microlearning videos?
 - e. How often did you return to the DO-MDD?
2. Could you share your experiences using the DO-MDD framework?
 - a. Have you previously designed and developed lessons that similarly followed the design and development of microlearning lessons using the DO-MDD framework?

- b. How was your experience using the DO-MDD framework when designing video lessons for the python unit?
3. Could you share some of the challenges you may have faced when using the DO-MDD framework when you designed python video lessons?
 - a. What are some of the areas that could be improved?
4. Could you share some of the aspects you liked about the DO-MDD framework?
5. How was your overall experience using the DO-MDD framework when you designed python video lessons?
 - a. How was this experience compared to recording a traditional lecture video?
6. What were some of the observations of your students? Observations may include communication with students, student behavior (YouTube analytics), and student learning data (results from quizzes, assignments, and tests).
 - a. What were some challenges that your students seemed to have experienced?
 - b. What were some successes that your students seemed to have experienced?
 - c. Were there any significant observations obtained from the YouTube Analytics?
 - d. Were there any significant observations from student learning data (results from quizzes, homework, tests)?

To complement the instructor reflections and interviews, researcher video observations were used to analyze the structure, pacing, and instructional design elements present in the microlearning videos. Only one instructor was able to share their full set of recorded lessons, so these observations reflect a limited but illustrative view of how the DO-MDD framework was applied in practice.

Qualitative student data were collected through semi-structured Zoom interviews and open-ended questions from the online student questionnaire. An interview protocol was developed and was used as a guide for all interviews. See Appendix C for a complete interview protocol for student interviews. There are five main questions in the interview protocol to help obtain a deeper understanding of how microlearning lessons designed with the DO-MDD framework impacted students' learning. Each main question has several subtopics to capture detailed information and depth (Billups, 2019) about the students' experiences with microlearning-designed videos:

1. Could you share your experiences using the programming video lessons?
 - a. Have you previously taken courses that used a similar format as the programming lessons?
 - b. How was your experience using the video lessons for the programming unit?
 - c. Did you think the lessons were different from other lecture recordings? How did it feel different from other formats?
2. Could you share some of the challenges you may have faced using the programming video lessons?
 - a. What are some of the areas that could be improved?
 - b. Were there any other challenges related to accessing the content?
 - c. Did this experience meet your expectations?
 - d. What is your previous experience in this type of environment?
3. Could you share some of the aspects you liked when you used the programming video lessons?
 - a. What do you think about the design of the programming video content?
 - b. Is there a specific programming video that you liked?
 - c. Did this type of programming video lesson influence your desire to continue learning?
 - d. Were there specific aspects of the programming video that caught your attention?
 - e. Were there specific aspects of the programming video that made the content relevant or not relevant?
 - f. Were there aspects of the video that helped to build confidence in your programming scripting?
 - g. Were there aspects of the video that provided a sense of satisfaction after completion of the programming video lessons?
4. Was there a specific technology that you preferred to use when learning with the programming video lessons?
 - a. Why did you use this and not a mobile device?
5. How was your overall learning experience using the programming video lessons?

The online student questionnaire gathered qualitative data on students' experiences with microlearning video lessons designed with the DO-MDD framework. See Appendix B for the complete online student questionnaire. Specifically, question 37 asked about the frequency of lesson use, question 38 inquired about the type of technology students used to view the videos, and question 39 invited students to share their thoughts on the microlearning video lessons. The last item in the questionnaire asked for student volunteers to participate in a semi-structured interview to collect data about the instrumentation. If a student was interested, they were asked to leave their email address. The purpose of the semi-structured student interviews was to obtain a better understanding of the quantitative data collected from the online questionnaire.

Quantitative Instruments

To create a holistic account of the instructors' and students' experiences, three types of quantitative data were collected to complement the qualitative data. The first type of quantitative data captured student behavior from YouTube Analytics, including frequency of video usage, time spent on each video lesson, and device usage. These data were available from two of the three instructors who hosted their videos on YouTube. The second type of quantitative data, obtained through instructor interviews and journal entries, included student learning data from assignments and quizzes to understand the impact on microlearning videos on student achievement. The last type of quantitative data came from the IMMS questions in the online student questionnaire.

The online student questionnaire gathered quantitative data on the experiences of student volunteers with the DO-MDD designed microlearning lessons. Items in the online questionnaire included 40 items, 36 of the items were modified from John Keller's (2010) Instructional Methods Motivational Survey (IMMS) to fit the microlearning context. These questions were modified with the inclusion of the term "programming" before "lesson" to specifically reference the content being taught. These modified items were tested in a pilot study to ensure validity and reliability. The IMMS instrument was chosen due to the specific intention to measure elements of motivation that could lead to student learning (Lajane et al., 2021; Li & Keller, 2018; Tunur et al., 2021).

The questions, while retaining their original focus on motivation, were adapted for a predictive purpose to gauge students' likelihood of continued use and preference for learning

programming through the microlearning lessons designed with the DO-MDD framework. Specifically, the ARCS model was employed to assess how well the lessons captured students' attention, the perceived relevance of the content, and students' confidence in continuing their learning with microlearning videos. Research (Li & Keller, 2018; Lo et al., 2022; Mohamed Yunus & Paimin, 2019; Tsai et al., 2022) suggests that effectively capturing motivational elements can provide valuable insights into students' engagement patterns, which can indicate the likelihood of continued use of the learning approach.

Data Collection

Journals, interviews, questionnaires, student learning data, student behavior data, and researcher video observations were the six types of methods of data collection for this study. Instructor self-reporting reflective journals were collected from the instructors that designed and implemented mobile microlearning-designed interventions using the DO-MDD framework. A journal allowed for the collection of information at a convenient time for the instructors, and saved the researcher time from transcribing (Creswell & Creswell, 2018). The microlearning designed interventions were accessible to students enrolled in those instructors' courses during the Fall 2023 and Spring 2023 semesters. After the completion of the intervention, students had access to assignments and quizzes provided by their instructor. The collection of assignments and quiz results was intended to serve as comparative data between current and past courses. However, the availability of such data varied. One instructor provided results from both current and prior semesters, while the other instructors only provided data from the implementation semesters. All data collected did not require any personal identifiable student information. After completion of the programming unit or activity, students were asked to complete an online questionnaire. Online questionnaires provided a quick and convenient way to collect quantitative data of trends, attitudes, and opinions of participants' statements (Creswell & Creswell, 2018; Flick, 2020). An email that contained information about the purpose of the study was provided to students prior to their access to the online questionnaire so that students were advised that it is their choice to participate. If a student wished to participate in the semi-structured interview, they were asked to leave their email at the end of the online survey. There were two types of interviews, instructor and student interviews. Within a two-month period, all interviews were

conducted in Zoom and audio recorded with Easy Voice Recorder. YouTube Analytics collected data on student behavior and their interactions with the microlearning-designed video lessons. Researcher video observations of selected microlearning lessons were also conducted as part of the data collection process.

Data Analysis

Once the data were collected, the researcher analyzed it using an open coding method, where themes emerge directly from the data (Bingham, 2023; Schoch, 2020; Williams & Moser, 2019). All data for this study were collected electronically. To ensure that all files were kept confidential and were properly stored, the researcher purchased an external drive, encrypting and password protecting it. Before analysis, all data were de-identified to ensure participant anonymity. The instructors' self-reflective journals were coded for common themes related to their perceptions with designing and implementing mobile microlearning designed lessons with the DO-MDD framework, providing insights to research questions 1, 2, 3, and 5. Student questionnaire data were coded for similar themes to help address research questions 4 and 5. After the instructor interview and student interview recordings (audio-only) were transcribed with Adobe Premiere Pro and manually checked for accuracy, the researcher applied open coding to the transcribed interviews to identify emerging themes. Themes emerging from instructor interviews addressed research questions 1, 2, 3, and 5, while student interview themes provided insights into research questions 4 and 5. Additionally, researcher video observations were reviewed to provide objective insight into how the DO-MDD framework was applied in practice, contributing to the interpretation of findings for research question 2. Results from assignments and quizzes were collected to be used as comparative data between current course sections, and past course sections to address research questions 3 and 5. To provide additional insight into research question 5, student behavior data from YouTube Analytics tracked student interaction data with the microlearning video by monitoring frequency of views and device usage. See Table 2 for the alignment of instruments to research questions.

It is important to note that not all instruments were used uniformly across participants to explain variation in student performance data. While all instructors provided self-reflective journals and participated in interviews, the availability of student performance data and YouTube

Analytics data differed. One instructor provided data across multiple semesters for comparative purposes, another shared general grade trends without specific breakdowns, and a third shared detailed results for a single semester without prior benchmarks. Similarly, only two instructors hosted videos on YouTube and were able to provide analytics, while the third used a different platform that did not generate comparative data. These differences reflect the flexible and multi-faceted nature of case study research, which allows for multiple sources and forms of data to be collected across participants (Yin, 2018). As Yin (2018) explains, case study design is an all-encompassing mode of inquiry that accommodates variations in data collection and analysis strategies. These differences reflect the natural variations found in case study research and were taken into account during the interpretation of the findings, particularly when drawing conclusions related to student performance and video engagement.

Validity & Reliability

To ensure the validity and reliability of the study, multiple strategies were incorporated throughout the study's process.

Pilot Study

To ensure the validity and reliability of the modified IMMS questions in the online questionnaire, interview instruments, and self-reflective journal prompts, a pilot study was conducted to refine questions prior to implementation of the main study (Ary et al., 2019; Gesser-Edelsburg et al., 2020). The goal of the pilot study was to gather feedback to refine the instruments and make any necessary revisions to the instruments and ensure they effectively address the research questions (Ary et al., 2019). One instructor from a college in Hawai'i and five students were recruited to participate. The instructor created one microlearning video lesson designed with the DO-MDD framework. After using the microlearning videos, five students participated in the online student questionnaire. Two of the five students indicated that they would participate in the student interview, however both students failed to respond to two email invitations sent by the researcher. Since the instructor from the pilot study also volunteered to participate in the main study and student interviews were not conducted, a programming instructor from a different college in Hawai'i and a former computer science student met with the researcher to go through the instructor and student interview questions. Two expert reviewers

and the researcher's dissertation committee provided suggestions for any necessary changes to the self-reflective question prompts. These expert reviewers were identified based on expertise with instructional design, specifically for mobile learning.

The pilot study also served to validate the modified IMMS items in the online student questionnaire. To assess internal consistency of the instrument, Cronbach's alpha was calculated across all 36 IMMS items, resulting in a high reliability score ($\alpha = 0.94$). This strong alpha value suggested the instrument demonstrated acceptable internal consistency, even with a small sample ($N=4$), and was considered appropriate for use in the main study.

Triangulation

In addition to the pilot study, triangulation was employed by gathering different types of data sources. Member checking was performed after all but one interview, and interrater coding was used with Krippendorff's alpha to measure coding agreement. Additionally, rich, thick descriptions provided a clear understanding of the framework.

The purpose of triangulation in this study was to collect data through multiple sources to help strengthen reliability and validity (Creswell & Creswell, 2018) through at least two different sources (Flick, 2020). The idea behind triangulation is that the combination of multiple sources of data would provide a greater depth and breadth of the data (Billups, 2019; Jentoft & Olsen, 2019) that could not be obtained through the collection of one data method (Flick, 2020). As depicted in Table 4, there are seven sources of data that were collected for this study: instructor self-reflective journals, instructor semi-structured interviews, student semi-structured interviews, student online questionnaire, results from student learning data, student behavior data, and researcher video observations. Results from student learning data include things such as assignments and quizzes. YouTube Analytics provided student behavior data.

Table 4*Alignment of Instruments with Research Questions and Tool Type*

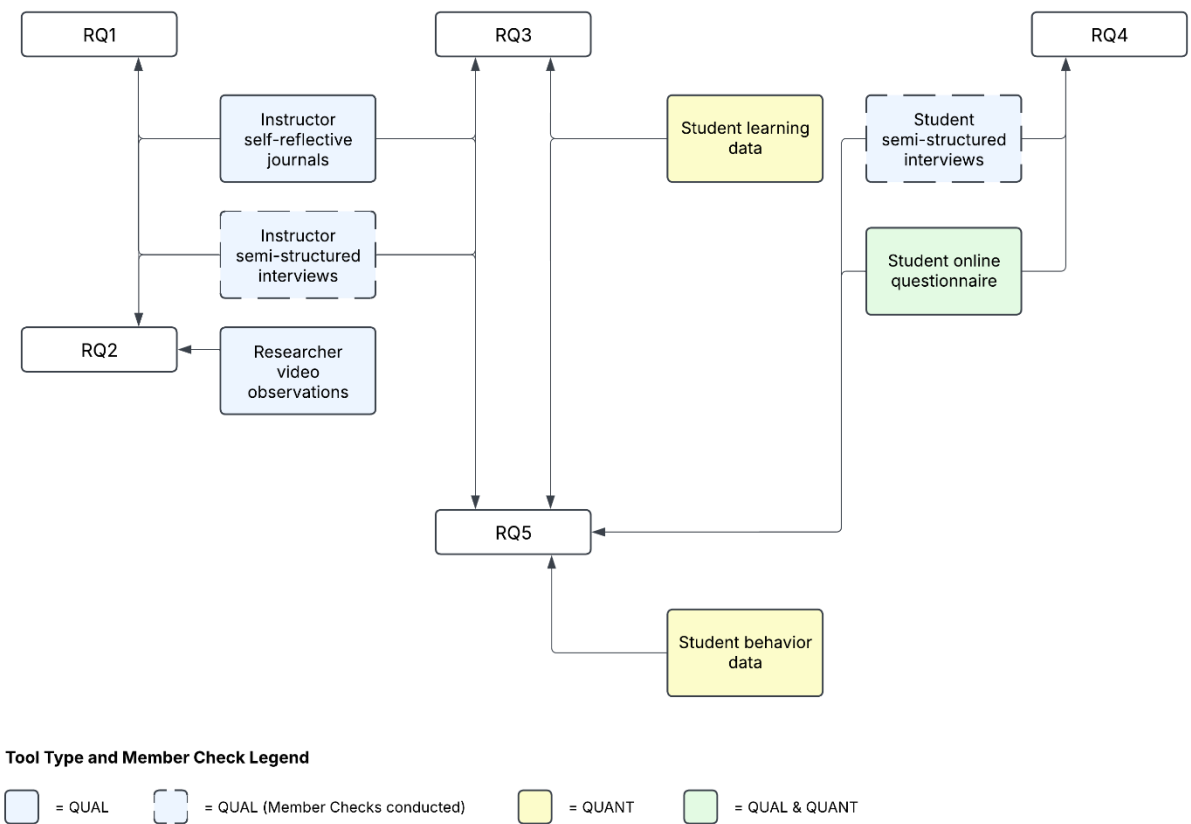
Instrument	Research Question	Tool Type
Instructor self-reflective journal	RQ 1, RQ 2, RQ 3, RQ5	QUAL
Instructor semi-structured interview	RQ 1, RQ 2, RQ 3, RQ 5	QUAL
Student semi-structured interviews	RQ 4, RQ 5	QUAL
Student online questionnaire	RQ 4, RQ 5	QUAL & QUANT
Student learning data (result from assignments and quizzes)	RQ 3, RQ 5	QUANT
Student behavior data (YouTube Analytics)	RQ 5	QUANT
Researcher video observation	RQ 2	QUAL

Each data source was aligned with specific research questions to provide insights into different aspects of the study. Instructor self-reflective journals and instructor semi-structured interviews provided insights on the design and implementation of the microlearning lessons designed with the DO-MDD framework, contributing to research questions 1, 2, 3, and 5. Student semi-structured interviews provided qualitative data for research questions 4 and 5. The student online questionnaire provided both qualitative and quantitative data to address research questions 4 and 5. Student learning data provided objective measures of student performance, contributing to the answer for research questions 3 and 5. Additionally, student behavior data, tracked YouTube Analytics, helped assess student engagement with the microlearning videos and supported research question 5. Researcher video observations of selected instructor-created microlearning lessons also contributed to the interpretation of how the DO-MDD framework was applied in practice, supporting findings for research question 2. By triangulating these diverse data sources, this study aimed to provide a comprehensive and robust picture of instructor and student perspectives, engagement, and performance. In addition, member checking was carried

out through follow-up interviews with both instructors and students to verify the accuracy and trustworthiness of the findings. This process contributed to triangulation by validating the data across different sources. Figure 3 further illustrates the alignment of data sources with the research questions.

Figure 3

Schematic Representation of Data Triangulation and Member Checks



Member Checking

As part of the instructor semi-structured interview process and the student semi-structured interview process, member checking was applied to help determine the accuracy of the findings

from the interviews (Creswell & Creswell, 2018). Member checks were conducted as follow-up interviews with both instructors and students. All three instructors participated in a member check for each semester they participated in the study, while five out of six students participated in a member check. During these member checks, participants were asked to review the findings or major themes from their interviews to ensure those findings were reflected accurately by the researcher (Billups, 2019; Creswell & Creswell, 2018; Flick, 2020). A member check was also applied to the instructors' self-reflective journals to help determine the accuracy of the interpretations of findings or major themes.

Interrater Coding

Interrater coding was performed to strengthen the reliability of the coding process (Cheung & Kai, 2021; Cole, 2023; Marzi et al., 2024). The researcher used an open coding method for the initial data analysis, allowing themes to naturally emerge from the data. Two different reviewers were chosen due to relevant experience to help reduce biases and increase reliability (Krippendorff, 2022). One reviewer recently completed their dissertation, and the other is from a different program who was at a similar stage in the dissertation process. An initial meeting was held between the researcher and both reviewers to compare their assessment of themes identified in the sample data. The sample data included an instructor interview, an instructor journal, a student interview, and qualitative data from the student questionnaire. The researcher developed 14 codes and provided the codes to the reviewers to apply to all four data samples. The reviewers were allowed to apply multiple codes to each sample data. After the coding was completed, the researcher held separate Zoom meetings with each reviewer to discuss coding results. Both reviewers suggested consolidating codes to increase agreement.

Krippendorff's alpha (α) was used to assess interrater reliability because it accommodates the complexity of multi-valued coding conducted by more than two coders (Krippendorff, 2022; Marzi et al., 2024). Krippendorff's (2004, 2018, 2022) standards were used to interpret Krippendorff's alpha: $\alpha = 1.000$ near perfect agreement, $\alpha \geq 0.800$ reliable agreement, $0.667 \leq \alpha < 0.800$ moderate agreement, and $\alpha < 0.667$ unreliable agreement. Krippendorff's alpha calculated the interrater reliability of the four sample coding items and found that only the instructor journal ($\alpha = 0.67$) suggested a moderate agreement between coders while the instructor interview ($\alpha = 0.54$), the qualitative data from the student questionnaire ($\alpha = 0.36$), and the

student interview ($\alpha = 0.35$) displayed unreliable agreements. Due to the low agreement scores, the researcher consolidated the codes based on suggestions from the two reviewers. The sample data was recoded, and Krippendorff's alpha was recalculated. The second round of Krippendorff's alpha calculations provided reliable results: $\alpha = 0.91$ (instructor interview), $\alpha = 0.89$ (instructor journal), $\alpha = 0.86$ (qualitative data from student questionnaire), and $\alpha = 0.81$ (student interview).

Rich Thick Descriptions

While conveying the findings, rich thick descriptions of the context of the study were applied to the findings to assist anyone with a good framework to allow others to follow and conduct similar studies (Creswell & Creswell, 2018). For this study, detailed descriptions from student participants and the instructors were also incorporated to provide a breadth of rich, thick descriptions of the study (Rose & Johnson, 2020). Providing a rich thick description of the study allows the reader to have an intricate understanding of the feelings and actions that occurred for the students and instructors (Creswell & Creswell, 2018).

Timeline

The study timeline began at the end of October 2022 with IRB approval to conduct a pilot study to test the instruments. The full study took place in the Spring and Fall 2023 semesters. Follow-up interviews did not extend beyond February 2024.

Product

This study produced questionnaire results with Google Forms, and recorded interviews saved as audio files with Easy Voice Recorder. The audio files were transcribed using Adobe Premier Pro and digitized into document files. The product of the questionnaire was compiled into a summary report that included qualitative and quantitative summaries.

Summary

The purpose of this case study was to investigate the effectiveness of the DO-MDD framework in designing mobile microlearning content, from the perspectives of both instructors and students. The study was conducted across three instructional modalities: online, hybrid, and

face-to-face. A total of three instructors and 38 students participated in semi-structured interviews, self-reflective journals (instructors), an online student questionnaire, behavioral analytics, and learning analytics, to assess the framework. The collected data were analyzed for recurring themes to answer the research questions and assess the framework's effectiveness. The next chapter presents the results, offering insights into the effectiveness of the DO-MDD framework.

CHAPTER 4. FINDINGS

The purpose of this case study was to examine if the Designing for One - Microlearning Design & Development (DO-MDD) framework is an effective tool to use to design microlearning lessons for mobile learning in college programming classes. This study unveiled the perceptions of three college programming instructors who designed lessons using the DO-MDD framework, and the perceptions of their students who learned a programming language with those lessons. As the literature indicated, there is a gap in design standards for mobile learning (Gong & Tarasewich, 2004; Li & Luximon, 2020; Ofori & Lockee, 2021; Punchoojit & Hongwarittorn, 2017). This study addressed this gap through exploring the experiences of college programming instructors who utilized the DO-MDD framework, and students who learned with lessons designed with the DO-MDD framework. This chapter presents the results of this case study using both qualitative and quantitative data analysis methods.

Pilot Study

Prior to conducting the larger study, the researcher implemented a small-scale pilot study to test the validity of the modified questions from the online student questionnaire, as well as the semi-structured instructor and student interview questions. The online student questionnaire included 40 questions: 36 modified items from John Keller's (2010) Instructional Methods Motivational Survey (IMMS), three open-ended questions about students' technology and video usage, and one question inviting volunteers to participate in a semi-structured interview. The pilot study, administered in an online programming course during the Fall 2022 semester, was designed to evaluate functionality of the instruments and identify any issues prior to full implementation.

As stated, through the pilot study, the reliability of the modified IMMS was examined by calculating Cronbach's alpha across all 36 items. The result yielded a strong internal consistency score ($\alpha = 0.94$), supporting the instrument's overall reliability. Given the small sample size ($N = 4$), these findings were interpreted as sufficient to proceed with the full study. The pilot findings confirmed that the IMMS items functioned as intended and supported their continued use.

Due to the difficulty of securing interview commitments from students, a former computer science student, who had not been exposed to the microlearning lessons, was interviewed solely to test the clarity and verbiage of the student interview questions. Additionally, the instructor who created microlearning videos for the pilot study also volunteered to participate in the main study. To test the verbiage of the instructor interview questions, another instructor in a related discipline, who was not involved in the pilot, was interviewed for feedback on question clarity and structure.

Description of Participants

The study focused on the perceptions of college programming instructors and perceptions of their students. Specifically, there were a total of three college programming instructors who teach at a college in the state of Hawai'i. One instructor created videos using the DO-MDD framework for online courses taught during the pilot phase (Fall 2022) and implementation phases (Spring 2023 and Fall 2023). Another instructor created videos using the DO-MDD framework for online and hybrid courses during the Fall 2023 semester, while the third instructor created a video using the DO-MDD framework for a face-to-face course during the Fall 2023 semester. The student participants were students who were enrolled in one of the instructors' courses during the Spring 2023 and Fall 2023 semesters. There were 38 students who participated in the online student questionnaire. Of the 38 students, six students participated in interviews.

Results

This study included data collected from an online student questionnaire which consisted of quantitative questions from the IMMS questions as well as qualitative data obtained through open-ended questions. Interview recordings (audio-only) of three college programming instructors and six students of those instructors, instructor self-reflection journals, student learning data obtained from assignments and quiz results, and student behavior data obtained from YouTube Analytics were also collected. In addition, the researcher conducted an observational review of selected instructor-created microlearning video lessons to better understand how the DO-MDD framework was applied in practice and to support interpretation of

reported experiences. The quantitative IMMS data from the online student questionnaire was analyzed using Google Sheets to calculate descriptive statistics, including means and standard deviations for each ARCS element. YouTube Analytics data, such as total views and device types used to access the microlearning videos, were also analyzed using basic descriptive measures to support insights about student engagement. The interviews were transcribed verbatim with Adobe Premiere Pro, and then manually checked for accuracy. The transcribed interviews, instructor self-reflection journals, and the open-ended questions from the online student questionnaire were coded by the researcher.

The results of the study are organized according to the research questions:

1. How did the instructors use the DO-MDD framework?
2. What are the instructors' perceptions of the DO-MDD framework?
3. What are the instructors' perceptions of students' learning using the lessons designed based on the DO-MDD framework?
4. What are students' perceptions of lessons based on the DO-MDD framework?
5. How do lessons based on the DO-MDD framework hinder/enhance student learning?

The first two results subsections focused on instructor perceptions related to the DO-MDD framework to address research questions 1 and 2. Results from the instructor self-reflective journals and interviews provided insights into the instructors' perceptions during both the construction and implementation stages of the DO-MDD framework. To further support the interpretation of instructor-reported data for research question 2, the researcher also conducted an observational review of selected instructor-created microlearning video lessons. This provided an additional lens for understanding how the framework was applied in practice. The third results subsection presents instructors' perceptions of their students' learning with the DO-MDD designed lessons. These perceptions were supported by student learning data, which complimented insights gathered from the instructors' self-reflective journals and interviews. The fourth results subsection analyzed data from the online student questionnaire, and student interviews to describe students' perceptions of the lessons that were designed using the DO-MDD framework to address research question 4. To answer research question 5, multiple data collection methods were utilized and are presented in the last results subsection. These included instructor self-reflective journals, instructor and student semi-structured interviews, the student

online questionnaire, student learning data, and student behavior data. These methods were integrated to delve deeper into the effectiveness of learning with video lessons created using the DO-MDD framework, with a particular focus on student success.

While the following results focus on overarching themes across all instructors, it is important to note that some themes emerged from the shared experiences of two instructors rather than all three. This distinction is particularly relevant when interpreting feedback related to different teaching formats, such as face-to-face, hybrid, or online, as these offer unique insights into how the microlearning lessons were applied. Therefore, these findings offer valuable perspectives on how the DO-MDD framework may be adapted to various instructional settings.

RQ 1: Instructors' Use of the DO-MDD Framework

Instructors utilized the DO-MDD framework in varied ways as they developed their microlearning video lessons. Although their self-reflective journals and interviews indicated that each instructor spent different amounts of time on each phase, two prominent themes stood out regarding the development of their video lessons: (1) student-centered content analysis and (2) framework-driven adaptation. Each of the themes identified were supported by several sub-themes that helped to depict how the instructors designed their microlearning video lessons with the DO-MDD framework. Table 5 provides a condensed version of Theme 1 and sub-themes along with selected coded excerpts from the instructors' self-reflective journals and interviews. For a full list of all coded excerpts, see Table D1, in Appendix D.

Table 5

Themes Reflecting Instructors' Use of the DO-MDD Framework in Microlearning Video Design (Research Question 1)

Theme	Category	Participant Code	Coded Excerpts
Student-Centered Content analysis	Assessed students' needs	Instructor 01	"Before creating the microlearning lesson, I started with analyzing what my students' needs were from a previous class session in regards to their understanding with coding and if they were comfortable with coding."
		Instructor 03	"It made me think about what was most important and try to emphasize those parts."
	Identified break points	Instructor 02	"I tried to split it up into kind of like the main content, like the different parts."
		Instructor 03	"Some lessons were easier to convert to microlearning lessons than others. The easiest lecture to convert was the lecture Program Arguments, Exceptions, Regex, due to the clearly distinct topics in that lecture."
		Instructor 03	"So in terms of making sure that there are activities to ensure that that are in line with the videos, I mean, that was already in place. My main focus was how to split up the videos, making sure that what I cover in the video, in the original video was still maintained in the smaller videos because some of the questions that I ask on the quiz or some of the things that I asked them to do for an assignment are directly in line with the video."
		Instructor 03	"So my main focus was to ensure that when I did break up the video, it still maintained the original essence, but it allowed me to update some of the slides and some of the examples."

Theme	Category	Participant Code	Coded Excerpts
Framework-driven adaptation	Student-centered design	Instructor 01	“During the design and development of the lesson, based on the students' understanding and comfortability with coding, these items determined how much explanation I needed to do on concepts and code, how much interaction (back-and-forth) I will have with the students, and how much coding items of the topic I will cover.”
		Instructor 02	“I used the DO-MDD framework to decide how to break up the material into separate videos. I began by identifying the needs. By identifying what concepts I wanted students to get out of the lesson, I was able to pinpoint a “goal” for each video. The goals were what I centered the design and development steps around.”
	Engagement focused	Instructor 03	“Following along with the code demonstration provides students with “hands-on” practice. To ensure students internalized the concepts of the lectures, there was a weekly quiz and weekly programming assignment. The weekly quiz consisted of five to seven open response questions.”
		Instructor 03	“The weekly programming assignment involves the student incorporating concepts that were presented during the week to create a program. In most cases, students create a program from scratch, in other cases, students are provided starter code that is to be modified based on specifications of the program. For example, one assignment involves students creating a Python program that reads in a text file of potential credit card numbers and categorizes them based on the card network. In another assignment, students define functions that mimic a grocery list.”

Theme	Category	Participant Code	Coded Excerpts
	Continuous reflection and iteration	Instructor 01	“At the ending of the day, I reflect and write down on my personal syllabus that is not shared with the class on what we covered, what did not work, and what worked well. Then analyze the needs to continue with the lesson, revisit a previous lesson, or adjust and adapt my new lesson from what I learned in my previous class session.”
		Instructor 03	“In the analysis phase of the DO-MDD framework, it is always a good idea to take stock and ensure that the lessons that are being created are in line with the learning objectives.”

“Student-Centered Content Analysis” was a prominent theme that stood out when instructors described how videos were broken up. This analysis revealed the following two sub-themes: (1) assessed students’ needs and (2) identified break points. The first sub-theme, “assessed students’ needs” emerged during the Analyze phase of the DO-MDD framework. Instructor 01, Instructor 02, and Instructor 03 commonly shared how the framework had them more focused on their students’ needs rather than on the amount of content that needed to be covered. Instructor 03 expressed, “It made me think about what was most important and try to emphasize those parts.” Similarly, Instructor 01 shared, “I started with analyzing what my students’ needs were from my previous class session.”

Although all instructors focused on students’ needs, two of the three instructors have traditionally created lectures that often lasted for more than an hour for their online and hybrid courses. This experience brought about the second sub-theme, “identified break points,” as both Instructor 02 and Instructor 03 shared how they took topic relevance into consideration when breaking up their content into topic-specific microlearning videos. Instructor 02 said, “I tried to split it up into kind of like the main content, like the different parts,” and Instructor 03 shared, “Some lessons were easier to convert to microlearning lessons than others. The easiest lecture to convert was the lecture Program Arguments, Exceptions, Regex, due to the clearly distinct topics in that lecture.”

Instructor 03 also discussed the challenge of maintaining the integrity of the original lesson while breaking it into smaller videos. “My main focus was how to split up the videos, making sure that what I cover in the video, in the original video was still maintained in the smaller videos,” shared Instructor 03. This reflection emphasizes the internal process of dividing the original video lessons into smaller, focused segments to ensure that the main ideas remain consistent. Additionally, Instructor 03 focused on aligning video content with existing activities such as quizzes and assignments sharing, “Some of the questions that I ask on the quiz or some of the things that I asked them to do for an assignment are directly in line with the video.” This approach helped Instructor 03 “to ensure that when I did break up the video, it still maintained the original essence.”

The second main theme, “Framework-Driven Adaptation,” highlights how student-centered content analysis served as a foundation for the instructors’ design and development process, with reflective adjustments on outcomes to ensure alignment with student learning needs and objectives. This theme was broken down into three sub-themes: (1) student-centered design, (2) engagement focused, and (3) continuous reflection and iteration. The first sub-theme, “student-centered design,” revealed how the Analyze phase of the DO-MDD framework influenced instructors' microlearning video development decisions in the Design and Development phases. Instructor 02 explained:

I used the DO-MDD framework to decide how to break up the material into separate videos. I began by identifying the needs. By identifying what concepts I wanted students to get out of the lesson, I was able to pinpoint a “goal” for each video. The goals were what I centered the design and development steps around.

Instructor 01 also emphasized a student-centered design, explaining that the students’ understanding and comfort level with coding, “determined how much explanation I needed to do on concepts and code, how much interaction...with the students, and how much of the topic I will cover.”

While the first sub-theme focused on creating content centered around student needs, the second sub-theme, “engagement focused” emphasized the importance of hands-on, interactive elements to help students internalize programming concepts. All three instructors emphasized this approach through activities such as coding exercises, quizzes, and programming

assignments. For example, Instructor 03 provided students with “hands-on” practice that allowed “students create a program from scratch, in most cases, students are provided starter code that is to be modified based on specifications of the program.”

The first and second sub-themes reflected practices commonly associated with the Design and Development phases of the DO-MDD framework. While the last sub-theme, “continuous reflection and iteration” illustrates how instructors engaged in ongoing reflective practice throughout and beyond the initial implementation of their microlearning lessons. During the design and implementation phases, instructors were asked to maintain a self-reflective journal, utilizing prompts to facilitate their reflections. While the prompts did not specifically focus on continuous reflection, instructors described revisiting earlier phases of the framework and made adjustments based on student needs and learning outcomes. For example, Instructor 01 mentioned engaging in ongoing reflection, “At the ending of the day, I reflect and write down...what did not work, and what worked well.” Similarly, Instructor 03 shared, “In the analysis phase of the DO-MDD framework, it is always a good idea to take stock and ensure that the lessons that are being created are in line with the learning objectives.” These reflections demonstrate how the instructors engaged in iterative processes to refine content, evaluate effectiveness, and realign lessons with intended outcomes. Given the non-linear structure of the DO-MDD framework, continuous reflection is an inherent component of the process, helping to determine whether adjustments or adaptations were needed for future lessons.

Together, the “Student-Centered Content Analysis” and “Framework-Driven Adaptation” themes portrayed how instructors structured their lessons around targeted single objective lesson development using the DO-MDD framework. Although there were slight variations in each instructor's approach, all three instructors designed with their students in mind. Research question 2 will explore the instructors’ perceptions of the DO-MDD framework.

RQ 2: Instructors’ Perceptions of the DO-MDD Framework

Instructors’ reflections revealed key insights into the challenges and benefits of implementing the DO-MDD framework in their lesson design. The instructors’ self-reflective journals and interviews provided insights into their experiences and highlighted four central themes: (1) framework usability, (2) design concerns, (3) teaching effectiveness, and (4) framework impact. Each of the themes identified were supported by several sub-themes that

helped to depict the instructors’ perceptions of the DO-MDD framework. Additionally, researcher-conducted video observations offered an objective perspective on how instructional decisions, particularly around video pacing and segmentation, were applied in practice. Table 6 provides a condensed version of themes reflected by the instructors’ experience with the DO-MDD Framework and sub-themes along with selected coded excerpts from the instructors’ self-reflective journals and interviews. For a full list of coded excerpts, see Table D2, in Appendix D.

Table 6

Themes Reflecting the Instructors’ Experience with the DO-MDD Framework (Research Question 2)

Theme	Category	Participant Code	Coded Excerpts
Framework usability	Ease of use	Instructor 01	“Pretty easy to follow.”
		Instructor 03	“It was pretty straight forward.”
	Adaptability	Instructor 01	“What’s nice is that...it’s like a cycle, so you can start in really any phase.”
		Instructor 03	“Since concepts are separated, it allows for new material to be added in the future. This is especially helpful in the technology field where things are always changing.”
Design concerns	Content organization	Instructor 01	“The challenges for designing included what concepts, what are items I need to emphasize or explain further to anticipate questions that I won’t be doing as the microlearning video is playing.”
		Instructor 01	“The only one I felt that was kind of enough detailed was like the analysis and then the reflection. Yeah, and implementation was pretty specific too. Yeah, but I feel like the design and development part, it felt a little

Theme	Category	Participant Code	Coded Excerpts
			empty. It didn't kind of give me what I was hoping to see.”
		Instructor 03	“I cannot guarantee that the students will watch videos in succession.”
		Instructor 03	“So one of the challenges was how am I going to layout each video on a web page for students to watch?”
	Video length & structure	Instructor 03	“Difficulty with knowing when to break it up and then if I had to think about the total length, then that would have just been something more that I had to worry about.”
		Instructor 03	“So that was still kind of a challenge for me is like, what is a good time length?”
Teaching effectiveness	Instructional efficacy	Instructor 02	“Trying to design multi-sensory/multi-modality content was a little challenging due to the content. With programming, I feel the most useful/effective way to learn is to simply write code. So, it was a little challenging to think of other activities for the students to do.”
		Instructor 03	“Additionally, some concepts do not make too much sense on their own.”
	Avoided burnout	Instructor 01	“I never did microlearning lessons, so it helped me understand and reflect on where students could burn out while learning about code.”
		Instructor 01	“Microlearning, I think is really helping in at least the framework and what I've been using it in regards to the big ideas from it, you know, giving the students short, I guess shorter activities instead of just doing a whole hour and a half where they just get burnt out, exhausted, and then when they come back to me, they don't have that positive feeling.”

Theme	Category	Participant Code	Coded Excerpts
Framework impact	Positive feelings	Instructor 01	“I really like the idea of microlearning and I incorporated it as part of my implementation of my class lesson.”
		Instructor 03	“From a computer resource perspective, resting, editing, and producing microlearning lessons has less strain on the system overall than compared to an hour long lesson. There were times when my computer started to lag while editing an hour long video.”
	Critical reflections	Instructor 01	“I’m truthfully not a big fan of doing videos.”
		Instructor 01	“I feel this is double work and takes up a lot of my time.”
		Instructor 03	“It was a challenge to split the lecture while maintaining the essence of the existing lectures. An initial approach was to break up the lecture into two pieces between the lecture and demonstration. However, that did not resonate with the idea of “micro” in microlearning.”

The first main theme, “Framework Usability” emerged from the instructors’ shared insights regarding the DO-MDD framework. Under this theme, two sub-themes became apparent: (1) ease of use, and (2) adaptability. The first sub-theme, “ease of use,” depicted how instructors appreciated the intuitive design of the DO-MDD framework. Instructor 03 said, “It was pretty straight forward,” and Instructor 01 similarly commented that it was, “Pretty easy to follow.” The simplicity of the framework allowed instructors to be open to future adaptations to their microlearning designed lessons.

Building upon this idea, the second sub-theme focused on “adaptability.” Instructor 01 pointed out that the cyclic nature of the DO-MDD framework allowed instructors to, “start in really any phase” to accommodate the specific needs of the lesson. While Instructor 03 pointed out the ease of which future changes could be made to record new lessons by saying, “Since

concepts are separated, it allows for new material to be added in the future. This is especially helpful in the technology field where things are always changing.” While these sub-themes explored the instructors’ positive experience with the framework, the second theme depicts concerns expressed by the instructors when they developed their microlearning lessons with the DO-MDD framework.

The second main theme, “Design Concerns” focused on instructor concerns that regarded video layout, delivery, length, and lesson structure. This theme was broken down into two sub-themes: (1) content organization and (2) video length & structure. The first sub-theme, “content organization,” focused on optimal delivery of information and the strategic design of learning modules. Concerns regarding how to determine the appropriate amount of content for a microlearning lesson was evident with Instructor 01. Instructor 01 mentioned, “The challenges for designing included what concepts, what are items I need to emphasize or explain further to anticipate questions that I won’t be doing as the microlearning video is playing.” Instructor 01 further reflected that the design and development phases “felt a little empty” because it lacked specific examples. In contrast, Instructor 03 shared how time was invested in the layout of how the microlearning videos were delivered on a webpage due to concerns about students watching videos non-sequentially.

The second sub-theme centered around “video length & structure.” Two of the instructors expressed difficulty in finding an appropriate balance to a “good time length.” Although the idea behind shortened videos was appealing, there was also a challenge in video segmentation. “Difficulty with knowing when to break it up and then if I had to think about the total length, then that would have just been something more that I had to worry about,” shared Instructor 03. Although these sub-themes shared instructors’ design concerns that surrounded learner outcome achievement, the third theme further explored instructors’ thoughts on effectiveness.

The third main theme, “Teaching Effectiveness,” delved deeper into the instructors’ thoughts around student engagement. Two sub-themes emerged: (1) instructional efficacy and (2) avoided burnout. Two of the instructors were concerned with information and activity relevancy of activities when using the DO-MDD framework for designing microlearning programming lessons. Instructor 02 commented:

Trying to design multi-sensory/multi-modality content was a little challenging due to the content. With programming, I feel the most useful/effective way to learn is to simply write code. So it was a little challenging to think of other activities for the students to do. This comment reveals the challenge of integrating other types of modalities beyond coding practice, as Instructor 02 felt that the most effective way to learn programming was through coding itself. To help capture the general idea of “instructional efficacy,” Instructor 03 also shared, “Additionally, some concepts do not make too much sense on their own,” pointing out the difficulty of breaking down specific programming concepts into standalone microlearning videos.

While the first sub-theme focused on instructional content, the second sub-theme, “avoided burnout” focused on how multiple instructors reflected on how breaking content into smaller segments helped students avoid cognitive overload and stay more engaged. For example, the framework affected in-person lesson planning for a Spring 2024 programming course. Instructor 01 shared, “I never did microlearning lessons, so it helped me understand and reflect on where students could burn out while learning about code,” which they felt helped curb coding fatigue in students during a Spring 2024 programming course. “Microlearning, I think is really helping in at least the framework and what I've been using it in regards to the big ideas from it, you know, giving the students short, I guess shorter activities instead of just doing a whole hour and a half where they just get burnt out, exhausted, and then when they come back to me, they don't have that positive feeling,” explained Instructor 01, to help students feel fresh and less exhausted when learning programming. These reflections were further supported by the researcher’s observational review of selected microlearning video lessons (see Appendix F, Table F1), which offered objective confirmation of these practices. The videos maintained a clear focus on a single objective, featuring short, focused segments and frequently incorporated examples or reflection prompts. In cases where lessons exceed 15 minutes, the additional time was primarily devoted to hands-on walkthroughs, indicating deliberate pacing intended to support student comprehension and minimize fatigue. The third theme, “Teaching Effectiveness” shared the instructors’ reflections on impactful decision making, the last theme delved into the instructors’ general reflections about the DO-MDD framework.

The last main theme, “Framework Impact” branched into two sub-themes: (1) positive feelings and (2) critical reflections. The sub-theme, “positive feelings” were expressed by all three instructors around practical benefits from microlearning lessons designed with the DO-MDD framework. Instructor 01 noted, “I really like the idea of microlearning and I incorporated it as part of my implementation of my class lesson,” while Instructor 03 elaborated on the technological efficiencies regarding system performance when creating video lessons, “From a computer resource perspective, creating, editing, and producing microlearning lessons has less strain on the system overall than compared to an hour long lesson. There were times when my computer started to lag while editing an hour-long video.”

Despite the overall positive responses from the instructors, the sub-theme “critical reflections” focused on instructors’ difficulties with aligning their existing methodologies with the DO-MDD framework. Instructor 01 shared a preference against creating video lessons because, “I feel this is double work and takes up a lot of my time.” Additionally, difficulties with identifying a method to divide existing video lessons and still meet the microlearning aspect of the DO-MDD framework was challenging. Instructor 02 explained:

It was a challenge to split the lectures while maintaining the essence of the existing lectures. An initial approach was to break up the lecture into two pieces between the lecture and demonstration. However, that did not resonate with the idea of “micro” in microlearning.

The instructors’ perceptions of the DO-MDD framework were portrayed through the exploration of four themes and their sub-themes. Collectively, the main themes presented the successes and struggles experienced by the instructors. Research question 3 dives into the instructors’ observations of their students’ learned experiences when their students used lessons designed with the DO-MDD framework.

RQ 3: Instructors’ Perceptions of Students’ Learning with the DO-MDD Framework

As frontline observers of student progress, instructors offered valuable insights into how the DO-MDD framework influenced student learning. The data collected from the instructors’ self-reflective journals, instructors’ interviews, and student learning data, such as assignments and quiz results, helped to provide how instructors viewed the DO-MDD framework’s impact on student learning. The following two themes emerged: (1) student satisfaction and (2) improved

student performance. Each of the themes identified were supported by sub-themes that helped to depict the instructors' perceptions of their students' learning with the DO-MDD framework. Table 7 provides a condensed version of themes that reflected Instructors' perceptions of students learning with the DO-MDD Framework and sub-themes along with selected coded excerpts from the instructors' self-reflective journals and interviews. For a full list of coded excerpts, see Table D3, in Appendix D.

Table 7

Themes Reflecting Instructors' Perceptions of Student Learning with the DO-MDD Framework (Research Question 3)

Theme	Category	Participant Code	Coded Excerpts
Student Satisfaction	Favored structure	Instructor 02	“Students provided positive feedback on the shorter videos, saying that they liked that it was split up into topics.”
		Instructor 03	“So it seemed like students were more open to the way that this was or they were open to how this unit was laid out.”
	Emotional wellbeing	Instructor 01	“Through my experience with programming classes...you know, it can become very exhausting and tiresome, like really you can get really tired. But it didn't they didn't look that. And then when they were done, when I was observing them, they seemed happy as well too.”
		Instructor 02	“By splitting the material into shorter segments to digest, students are less overwhelmed. This seems to allow students to better understand each concept presented, instead of being inundated with so much information.”
Improved Student Performance	Less questions	Instructor 01	“And I think the other piece to it was that I didn't get any questions. No one really asked me anything.”

Theme	Category	Participant Code	Coded Excerpts
		Instructor 02	“Just having less people come in for arrays. Kind of a noticeable drop too, because it’s one of the hardest, like the second hardest topic of the semester.”
	Higher scores	Instructor 02	“Overall it seems to me that students not only preferred the microlearning lessons, but performed noticeably better on coursework due to them”
		Instructor 03	“Looking at the Average and Over 70% metrics we can see that there was a generally favorable outcome in both metrics with a noticeable dip for Python Quiz 02. For all assessments, the Average percentage was in the low 80s to mid 90s and the Over 70% metric was met. Compared to spring 2023, all assessments were generally higher in both metrics with the exception of Python Quiz 02. However, the Over 70% metric was still met with 76.47% of students achieving at least a 70%.”

The first main theme, “Student Satisfaction,” offered instructors’ observations of students’ preferences regarding the new microlearning video lessons and included the following sub-themes: (1) favored structure and (2) emotional wellbeing. The first sub-theme, “favored structure” revealed students preferred the new video lesson format that was developed with the DO-MDD framework. Instructor 02 noted, “Students provided positive feedback on the shorter videos, saying that they liked that it was split up into topics.” A similar observation occurred in Instructor 03’s Fall 2023 sections where there were no negative comments regarding the microlearning format. Instructor 03 further explained that “it seemed like students were more open to the way that this was or they were open to how this unit was laid out.”

While the DO-MDD framework developed microlearning lessons were favored by the instructors’ students, two of the instructors shared how the format impacted their students’ “emotional wellbeing.” Instructor 01 pointed out that learning to code can be exhausting in nature, but noticed a shift with his students’ demeanor. According to Instructor 01’s

observations, students who completed the DO-MDD lesson did not look “exhausted and tiresome” and “they seemed happy as well too.” Instructor 02 shared a similar experience, “By splitting the material into shorter segments to digest, students are less overwhelmed. This seems to allow students to better understand each concept presented, instead of being inundated with so much information.” Building upon “Student Satisfaction,” the second theme focused on observed learner performance with video lessons created with the DO-MDD framework.

The second main theme, “Improved Student Performance” developed from two sub-themes: (1) less questions and (2) higher scores. The first sub-theme, “less questions” illustrated how each instructor experienced a reduction in questions from their students. Instructor 02 noticed a significant drop in students who came for help during open office hours, “Just having less people come in for arrays. Kind of a noticeable drop too, because it’s one of the hardest, like the second hardest topic of the semester.” In a comparable instance, Instructor 01 experienced a similar situation after students watched the microlearning video designed with the DO-MDD framework, “And I think the other piece to it was that I didn't get any questions. No one really asked me anything.”

The second sub-theme, “higher scores” focused on how two of the instructors observed an increase in student scores while one instructor noticed overall favorable outcomes in student assignments and quiz scores apart from a decline in performance for a python quiz in the Fall 2023 semester. Instructor 02 shared, “Overall it seems to me that students not only preferred the microlearning lessons but performed noticeably better on coursework due to them.” While Instructor 01 was surprised that, “Most of the scores were quite high for the assessment.” Although Instructor 01 felt the topic could have been easy, there was an expectation of a normal grade distribution for the quiz results. The quiz results indicated six students obtained a perfect score, three students scored 3 out of 4 points, and one student scored 2 out of 4 points.

Similarly, Instructor 03 observed overall favorable results in student performance that satisfied the Over 70% metric, colloquially known as “70 over 70,” a benchmark used to assess Student Learning Outcomes (SLOs). Specifically, the Over 70% metric represents the percentage of students that achieved a score of at least 70%. However, contrasting the overall positive results, Python Quiz 02 revealed a noticeably drop in scores. Instructor 03 reported:

For all assessments, the Average percentage was in the low 80s to mid 90s and the Over 70% metric was met. Compared to spring 2023, all assessments were generally higher in both metrics with the exception of Python Quiz 02. However, the Over 70% metric was still met with 76.47% of students achieving at least a 70%.

Table 8, Table 9, Table 10, and Table 11 compares summarizing grade percentages for Instructor 03’s Python Assignment 01, Python Assignment 02, Python Quiz 01, and Python Quiz 02 from Fall 2023 (FA23), Spring 2022 (SP22), Fall 2022 (FA22), and Spring 2023 (SP23). It’s important to note that while all four semesters are included for comparative purposes, only Spring 2023 and Fall 2023 reflect semesters when the DO-MDD framework was formally implemented by Instructor 03. Spring 2022 data represents a traditional teaching approach with no microlearning integration, while Fall 2022 reflects the pilot phase, where only some microlearning video content was created. The data presented in these tables offer context for understanding performance trends over time. However, the instructor’s own observations and conclusions were based specifically on the implementation period.

Table 8

Comparison of Student Performance in Python Assignment 01 Across Semesters

Semester	Grade Percentages						Summary Statistics	
	N	A	B	C	D	F	Over 70% ^a	Average Score
SP22	24	18 (75%)	5 (21%)	0 (0%)	0 (0%)	1 (4%)	23 (96%)	93%
FA22	27	27 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	27 (100%)	98%
SP23	22	15 (68%)	3 (14%)	2 (9%)	1 (5%)	1 (5%)	20 (91%)	90%
FA23	18	17 (94%)	0 (0%)	1 (6%)	0 (0%)	0 (0%)	18 (100%)	97%

^aOver 70% represents the percentage of students who scored at least 70%.

Table 9*Comparison of Student Performance in Python Assignment 02 Across Semesters*

Semester	N	Grade Percentages					Summary Statistics	
		A	B	C	D	F	Over 70% ^a	Average Score
SP22	22	14 (64%)	6 (27%)	0 (0%)	0 (0%)	2 (9%)	20 (91%)	86%
FA22	27	23 (85%)	3 (11%)	0 (0%)	1 (4%)	0 (0%)	26 (96%)	94%
SP23	21	18 (86%)	1 (5%)	0 (0%)	1 (5%)	1 (5%)	19 (90%)	91%
FA23	18	14 (78%)	4 (22%)	0 (0%)	0 (0%)	0 (0%)	18 (100%)	97%

^aOver 70% represents the percentage of students who scored at least 70%.**Table 10***Comparison of Student Performance in Python Quiz 01 Across Semesters*

Semester	N	Grade Percentages					Summary Statistics	
		A	B	C	D	F	Over 70% ^a	Average Score
SP22	27	16 (59%)	8 (30%)	2 (7%)	0 (0%)	1 (4%)	26 (96%)	86%
FA22	27	25 (93%)	2 (7%)	0 (0%)	0 (0%)	0 (0%)	27 (100%)	95%
SP23	23	16 (70%)	2 (9%)	3 (13%)	2 (9%)	0 (0%)	21 (91%)	88%
FA23	19	14 (74%)	4 (21%)	0 (0%)	0 (0%)	1 (5%)	18 (95%)	92%

^aOver 70% represents the percentage of students who scored at least 70%.

Table 11*Comparison of Student Performance in Python Quiz 02 Across Semesters*

Semester	N	Grade Percentages					Summary Statistics	
		A	B	C	D	F	Over 70% ^a	Average Score
SP22	23	7 (30%)	6 (26%)	6 (26%)	2 (9%)	2 (9%)	19 (83%)	77%
FA22	29	18 (62%)	7 (24%)	2 (7%)	2 (7%)	0 (0%)	27 (93%)	88%
SP23	23	17 (74%)	4 (17%)	1 (4%)	1 (4%)	0 (0%)	22 (96%)	92%
FA23	17	9 (53%)	3 (18%)	1 (6%)	1 (6%)	3 (18%)	13 (76%)	81%

^aOver 70% represents the percentage of students who scored at least 70%.

While Instructor 03 noted favorable overall performance, it is important to note that there was some variation in scores observed when comparing across semesters. The tables show trends where scores decrease in one semester compared to the previous semester but then increase in the subsequent semester. The observed variability in performance can be equated by several factors, such as content difficulty, timing in the semester, or other variables affecting student performance. According to Instructor 03, “The Python unit is the last unit of the semester, students may have been fatigued by other end of semester activities.” Nevertheless, the framework’s overall impact remained positive, as Instructor 03 reported that most students met the Over 70% metric on the four assessments.

The two main themes and their sub-themes helped to illustrate positive student behaviors observed by the instructors. It was evident that there was growing student satisfaction with microlearning lessons created with the DO-MDD framework, and instructors reported marked improvements in most of the quiz and assignment scores. Research question 4 dives into students’ experiences with video lessons designed with the DO-MDD framework.

RQ 4: Students' Perceptions of Microlearning Lessons Designed with the DO-MDD Framework

While instructors' experiences helped to provide valuable insights into the DO-MDD framework, student perspectives provided a more complete picture of the microlearning video lessons' impact. To paint a complete picture, the students' perspectives provided a well-rounded view of the impact of the microlearning video lessons designed with the DO-MDD framework. Overall student feedback gathered from student interviews and an open-ended question in the student questionnaire, revealed that students highly valued the microlearning video lessons designed with the framework. Also, results from the IMMS questions, the quantitative portion of the student questionnaire, as shown in Table 12, depicted a generally favorable student response to the DO-MDD designed video lessons.

Table 12

Mean and Standard Deviations for IMMS Results

ARCS Element	<i>M</i>	<i>SD</i>
Attention	3.95	0.97
Relevance	4.19	0.85
Confidence	3.84	0.95
Satisfaction	4.35	0.72

Note. $N = 38$. Scores were based on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). Reverse coding was applied to questions 4, 5, 8, 11, 12, 19, 23, 25, 27, and 29.

After reviewing the student interview data and the student questionnaire data, there were four main themes that became apparent: (1) flexible learning, (2) efficient learning, (3) impact of video length, and (4) improving the learning experience. Each of the themes identified were supported by sub-themes that helped to depict the students' perspectives of their learning with microlearning video lessons created with the DO-MDD framework. Table 13 provides a condensed version of themes that reflects students' experiences with videos created with the DO-

MDD Framework and sub-themes along with selected coded excerpts from the student online questionnaires and student interviews. For a full list of coded excerpts, see Table D4, in Appendix D.

Table 13

Themes Reflecting the Students' Experience with the DO-MDD Framework (Research Question 4)

Theme	Category	Participant Code	Coded Excerpts
Flexible Learning	Learning convenience	SQStudent 02	“I also appreciate that it's on youtube, so I can watch it on my tablet when I don't feel like turning on my laptop.”
	On-demand viewing	Student 02	“And then if I had to go and do something for my work, I could always pause it, you know, write down the time just in case it pauses me out when logging out of the LMS. And kind of write down the time when I stopped the video and then I can just go back and resume. So it's really flexible when it comes to that, which made it really easy, really easy for me to get through the course.”
		Student 06	“It was good because if you missed something unlike in real time, you could actually go back to rewind the video a bit and wait. Let me go back a little bit and see what I missed.”
Efficient Learning	Concentration enhanced	Student 04	“So I've really enjoyed that. It's made learning ICS, which is something completely new to me, a lot more manageable.”
		SQStudent 07	“I personally really like the idea of microlearning designed lessons because, tricking my brain with shorter videos made me stay focused and interested in

Theme	Category	Participant Code	Coded Excerpts
			the relating main topics of the python videos. Plus having separate videos for each topic in python was more manageable to remember and know how to write basic programs in python.”
	Structured clarity	Student 03	“Off the top of my head, loops was pretty helpful. Like it was broken down, broken down into three videos and you can get a little bit more detail on each type of loop.”
		Student 06	“Yeah, I think it was a lot more concise. So instead of having all this background extra in between talking, it was kind of just like, these are the main points. Here’s an example like, I like that it was streamlined and it wasn’t like you like when you take courses, sometimes you’re in the class and you’re like, Wow, this class really could have been an email.”
		SQStudent 19	“In my opinion, I think microlearning is great because, within a short amount of time, you can gather a lot of information rather than a long video that takes a long time to get the kind of content you need for your programming.”
	Ease of access	SQStudent 12	“It was much easier to go back and reference lectures for studying. The long format lessons were more difficult to go back and review material.”
		SQStudent 25	“I feel like these lessons are much more organized and easier to come back to when you are looking for a certain topic of python. When I needed more information on dictionaries, I easily just went back to the dictionaries video and found the example I was looking for.”

Theme	Category	Participant Code	Coded Excerpts
Impact of Video Length	Student Preference	Student 06	“When you click on a video that you get from a professor and it says like 40 minutes or an hour or something long. I feel like already then you're losing your audience because your students don't want to watch an hour long video. They're going to just skip through it and try to find important parts. But because it's so short, it's kind of already setting a precedent that everything is important and you don't even need to pay attention that long.”
		SQStudent 02	“It's nice when the lessons are short (under 10-15 minutes).”
	Supports learning	SQStudent 14	“They are helpful ways to learn in bite-size pieces.”
		SQStudent 21	“I think microlearning is a much better approach to learning new materials compared to a long hour and a half lecture where you can get stuck on the material while the professor continues the lecture.”
		SQStudent 26	“Although I already knew some python, I felt that these lessons gave me a better understanding of parts I was unsure about and helped me become better at python.”
Improving the Learning Experience	Desire for immediate feedback	Student 06	“The challenge is, I guess is that there's not really real time feedback. So if you do have any questions, you still have to go and message your professor and be like, Hey, I don't understand this, or can you explain this? Which isn't really a problem if it's like a smaller drawback. And the other thing is that depending on how familiar your professor is or the person who's teaching is with recording and teaching online or through videos is, if

Theme	Category	Participant Code	Coded Excerpts
			they're not used to it, they're not going to get their point across.”
		SQStudent 32	“I think it is a very functional, streamlined way to educate lots of people in diverse circumstances. Communication with the instructor is key, as not being able to ask questions is an enormous downside on the effectiveness of the learning session.”
	Targeted recommendations	Student 01	“The one suggestion or drawback you felt was that there should have been mini quizzes to also help supplement with the videos with reinforcement.”
		Student 05	“I think just the presentation could have been better if he had used like more PowerPoints or more like more visuals. I think visuals is what needed because when I was watching the videos, I kind of got lost. Also, it helps the videos help, but the same. Yeah, there's the visuals were were lacking.”
		SQStudent 02	“But then, there's a few videos that are really long (30 minutes or so) and that ends up feeling like the content is dragging. I would prefer each video to be similar length of time to the others instead of it being a vast difference of varying times for each one.”

The first main theme focused on “Flexible Learning,” specifically highlighting how the DO-MDD framework supported students’ needs for a customizable learning environment. This theme is supported by two sub-themes: (1) learning convenience and (2) on-demand viewing. The first sub-theme, “learning convenience” captured students’ appreciation of how the microlearning video lessons designed with the DO-MDD framework allowed students to personalize when and where they engaged with the microlearning videos. SQStudent 02 appreciated that lessons could be accessed on different devices which allowed lessons to be

viewed “on my tablet when I don’t feel like turning on my laptop.” Other students expressed how they valued the “focused content” because it was “convenient and digestible,” and the short microlearning lessons “fits well into busy schedules.” Supporting the students’ views, the IMMS data showed relatively favorable score for attention ($M = 3.95$, $SD = 0.97$) suggesting that the focused and flexible structure of the microlearning video lessons effectively captured and maintained students’ attention during the learning process.

The second sub-theme, “on-demand viewing” specifically highlighted the features of the microlearning lessons that allowed students to control the pace of their learning through the pause and rewind features of the video lessons. “It was good because if you missed something unlike in real time, you could actually go back to rewind the video a bit,” commented Student 06, emphasizing the benefit of being able to revisit specific parts of the video lesson. Similarly, Student 02 pointed out how “I can just go back and resume. So it's really flexible when it comes to that, which made it really easy, really easy for me to get through the course” amidst a busy work schedule. This flexibility was reflected in the IMMS attention score ($M = 3.95$, $SD = 0.97$) which suggests that students' engagement with the video lessons were generally positive, particularly in how the ability to control the pacing enhanced their learning experience. While the first theme focused on the students’ ability to learn at their own pace, the second theme delved deeper into microlearning lessons’ impact on learning from the students’ point of view.

The second main theme, “Efficient Learning,” addressed how learning was enhanced. This theme was supported by three sub-themes: (1) concentration enhanced, (2) structured clarity, and (3) ease of access. The first sub-theme, “concentration enhanced” revealed that students preferred the focused, bite-sized video lessons because they were “easier to digest” and helped them “focus on the objectives.” SQStudent 07 explained:

I personally really like the idea of microlearning designed lessons because, tricking my brain with shorter videos made me stay focused and interested in the relating main topics of the python videos. Plus having separate videos for each topic in python was more manageable to remember and know how to write basic programs in python.

Similarly, Student 04 shared how the shorter videos helped to make learning programming “a lot more manageable” for someone new to learning programming languages. The IMMS attention score ($M = 3.95$, $SD = 0.97$) aligns with the qualitative insights that students generally found the

DO-MDD video lessons engaging which may have contributed to their focus on the programming lessons.

While shorter videos helped students to have enhanced concentration, other advantages of this format extended to the structure of the microlearning video lessons. Students benefited from “structured clarity,” with short video lessons organized by singular objectives that “compound on top of each other.” Student 03 found the video lesson designed with the DO-MDD framework helped to learn about loops because it was “broken down into three videos and you can get a little bit more detail on each type of loop.” Other students liked how the videos were “a lot more concise” and “within a short amount of time, you can gather a lot of information rather than a long video that takes a long time to get the kind of content you need for your programming.” The IMMS results reinforced these perceptions, with the confidence score ($M = 3.84$, $SD = 0.95$) suggesting that students felt capable in understanding course material, likely due to the goal-orientated format of the microlearning video lessons.

The third sub-theme, “ease of access” revealed how students found it easy to navigate through the different microlearning video lessons to easily find material that needed to be revisited. SQStudent 12 said, “It was much easier to go back and reference lectures for studying. The long format lessons were more difficult to go back and review material.” The segmentation of the videos also helped students to figure out areas that did not require review and made it “easier to come back to when you are looking for a certain topic” to review. This is supported by the IMMS confidence score ($M = 3.84$, $SD = 0.95$), suggesting that the structure and accessibility of the microlearning video lessons designed with the DO-MDD framework promoted a sense of learner control and self-efficacy.

The third main theme, “Impact of Video Length,” described how the microlearning video lesson’s length played an impact on the learning process. There following two sub-themes emerged: (1) student preference and (2) supports learning. The first sub-theme, “student preference” reflected students' strong preference for short video lessons. Students shared that the concise format aligned with their learning preferences. “It’s nice when the lessons are short,” mentioned SQStudent 02, highlighting how videos should not exceed 15 minutes. Similarly, Student 06 shared videos that exceed 40 minutes are a turn off, and students would more likely “skip through it and try to find important parts.” These qualitative preferences were supported by

the IMMS attention score ($M = 3.95$, $SD = 0.97$) suggesting that students remained engaged with the video lessons designed using the DO-MDD framework.

The second sub-theme focused on how students viewed the microlearning video lessons designed with the DO-MDD framework as an approach that “supports learning.” Students articulated how the “bite-size” video length enhanced their ability to learn programming. “I think microlearning is a much better approach to learning new materials compared to a long hour and a half lecture where you can get stuck on the material while the professor continues the lecture,” SQStudent 21 pointed out. Even experienced programming students found the “bite-size” video lessons were beneficial. “Although I already knew some python, I felt that these lessons gave me a better understanding of parts I was unsure about and helped me become better at python,” shared SQStudent 26. The IMMS relevance score ($M = 4.19$, $SD = 0.85$) supported the students' views that the programming content in the DO-MDD designed microlearning video lessons were relevant. The IMMS attention score ($M = 3.95$, $SD = 0.97$) also suggested that the short “bite-size” video lengths helped maintain students' focus. Although students have shown a preference regarding specific aspects of video lessons designed with the DO-MDD framework, there is still room for improvement.

The last theme, “Improving the Learning Experience,” focused on suggestions students provided to improve the effectiveness of the learning experience. The following two sub-themes developed: (1) desire for immediate feedback and (2) targeted recommendations. The first sub-theme, “desire for immediate feedback” was a recurring theme that students expressed when engaging with the microlearning video lessons. SQStudent 32 shared, “I think it is a very functional, streamlined way to educate lots of people in diverse circumstances. Communication with the instructor is key, as not being able to ask questions is an enormous downside on the effectiveness of the learning session.” Similarly, Student 06 shared, “The challenge is, I guess is that there's not really real time feedback. So if you do have any questions, you will have to go and message your professor and be like, Hey, I don't understand this, or can you explain this?” Although the IMMS satisfaction score ($M = 4.35$, $SD = 0.72$) was relatively high, these comments suggest that satisfaction may have coexisted with unmet expectations for feedback. This may also help explain the slightly lower confidence score ($M = 3.84$, $SD = 0.95$), as students expressed how the lack of real-time feedback affected their ability to immediately grasp the

content. This suggests that while students were satisfied with the lesson structure, they may have lacked confidence in their understanding of the material, which could potentially be enhanced with real-time feedback.

While immediate feedback was of importance, students also provided “targeted recommendations” for other areas of improvement. These recommendations were focused on optimizing the learning process. Students indicated a need for “mini quizzes” to “help supplement with the videos with reinforcement,” improvement with presentation slides, and reducing the length of some of the video lessons. SQStudent 02 felt that some of the longer videos that extended 30 minutes felt like “the content is dragging,” and “would prefer each video to be similar length of time to the others instead of it being a vast difference of varying times for each one.” This feedback suggests that longer, inconsistent video lengths may have made it more difficult for students to stay engaged, as reflected in the slightly lower attention score ($M = 3.95$, $SD = 0.97$). This sentiment also aligned with the IMMS relevance score ($M = 4.19$, $SD = 0.85$). While students found the programming lessons relevant to their learning needs, they still sought ways to further enhance their engagement to have an optimal learning experience.

The four main themes and sub-themes illustrated a predominantly positive learning experience by students who learned with video lessons created with the DO-MDD framework. Students described areas of effectiveness that enhanced their learning and areas for improvement. Research question 5 goes into further detail of how lessons based on the DO-MDD framework hindered or enhanced student learning.

RQ 5: Impact of the DO-MDD Framework on Student Learning

To better understand how the DO-MDD framework hindered or enhanced student learning, data from multiple sources, including instructor interviews, instructor journals, student interviews, student online questionnaire, student learning data, and YouTube Analytics, were examined. The overarching theme “Learning Impact of Video Structure” emerged and is supported by two sub-themes: (1) fewer clarifications needed and (2) support for learning retention. These findings illustrate how the DO-MDD designed video lessons supported students in mastering programming concepts. Table 14 provides a condensed version of themes that reflects how lessons designed with the DO-MDD framework enhanced student learning and sub-

themes along with coded data from interviews, questionnaires, and analytics. For a more comprehensive list of all of the coded excerpts, see Table D5, in Appendix D.

Table 14

Themes Reflecting the Impact of the DO-MDD Framework on Student Learning (Research Question 5)

Theme	Category	Participant Code	Coded Excerpts
Learning Impact of Video Structure	Fewer clarifications needed	Instructor 02	“This past fall semester, I feel like I had less students asking questions.”
		Instructor 02	“Just having less people come in for arrays. Kind of a noticeable drop too, because it’s one of the hardest, like the second hardest topic of the semester.”
		Instructor 03	“It felt like I got less questions about certain things, so I would imagine that they just looked it up and it was easy to identify a video, and what they need to do.”
	Support for learning retention	SQStudent 14	“They are helpful ways to learn in bite-size pieces.”
		SQStudent 15	“They are a fantastic tool for helping students learn the content of their course.”
		SQStudent 16	“A fantastic way for students to learn the material from their course.”
		SQStudent 21	“I think microlearning is a much better approach to learning new materials compared to a long hour and a half lecture where you can get stuck on the material while the professor continues the lecture.”

Theme	Category	Participant Code	Coded Excerpts
		SQStudent 26	“Although I already knew some python, I felt that these lessons gave me a better understanding of parts I was unsure about and helped me become better at python.”
		SQStudent 34	“Microlearning lessons are a convenient way for me to learn. They provide focused content that is easy for me to understand and remember. I can quickly grasp specific concepts or skills without feeling overwhelmed. Microlearning offers flexibility and personalized learning, allowing me to choose when to learn. The modular nature of microlearning also allows me to easily review specific topics. Overall, microlearning is an effective way for me to gain knowledge.”
		Instructor 02	“In addition, the average grades for the quiz and assignment were higher!”
		Instructor 02	“Overall it seems to me that students not only preferred the microlearning lessons, but performed noticeably better on coursework due to them”
		Instructor 03	“In terms of viewer data from YouTube Analytics, the general trend was that students tend to view the videos when the quizzes and assignments are due. Quizzes were due Mondays and assignments were due Tuesdays. Most views were generated around that time frame from Sunday to Tuesday. This is in-line with previous semesters trends.”
		Instructor 03	“Looking at the Average and Over 70% metrics we can see that there was a generally favorable outcome in both metrics with a noticeable dip for Python Quiz 02. For all assessments, the Average percentage was in the low 80s to mid 90s and the Over 70% metric was met. Compared to spring 2023, all assessments were generally higher in both metrics with the

Theme	Category	Participant Code	Coded Excerpts
			exception of Python Quiz 02. However, the Over 70% metric was still met with 76.47% of students achieving at least a 70%.”

The first sub-theme, “fewer clarifications needed,” demonstrated a shared observation among all three instructors that the DO-MDD designed lessons helped students grasp complex concepts more effectively, resulting in a noticeable reduction in student questions. Instructor 03 pointed out, “It felt like I got less questions about certain things, so I would imagine that they just looked it up and it was easy to identify a video, and what they need to do.” Similarly, Instructor 02 observed a noticeable drop in “students asking questions” over one of their tougher topics, arrays. These observations are mirrored in the data, as shown in Table 15 where “Array Basics” accumulated 72 views, indicating that the DO-MDD framework allowed students to independently resolve their questions, reducing their reliance on an instructor for clarification.

Table 15

Fall 2023 YouTube Viewing Individual Video Data for Instructor 02

Video Number/Title	Computer Views	Mobile Phone Views	Tablet Views	Total Views
Video 1: Array Basics	64	7	1	72
Video 2: Array Properties	51	6	0	57
Video 3: Working with Arrays	54	7	1	62
Video 4: Copy, Search, Sort Arrays	42	3	1	46

This reduction in questions also aligns with students’ reported device usage. As shown in Table 16, most students accessed the DO-MDD videos on a weekly basis (13 out of 29 laptop users) or very often (7 out of 29 laptop users), with laptops the preferred device for 76% of

students. These insights were also supported by student behavior data collected from YouTube Analytics’ device usage statistics. Table 15, along with YouTube device usage data for Instructor 03 (see Table E1 and E2 in Appendix E), displayed high ‘computer’ usage by students. Although precise distinction is not made between laptops from desktops in YouTube Analytics, the overwhelming preference for laptops in the online student questionnaire suggested that the elevated computer statistics inferred that laptops were likely a major component of the ‘computer’ category. This consistent engagement with the DO-MDD videos seemed to help students to resolve their own questions about programming concepts.

Table 16

Student Reported Device Usage and Viewing Frequency of Videos Created with the DO-MDD Framework

Frequency	Mobile Phone	Tablet or iPad	Laptop	Desktop
Not Often	0	0	3	1
Few Times	0	0	5	0
Very Often	1	1	7	4
Weekly	0	1	13	2
Everyday	0	0	1	0
Total	1	2	29	6

The second sub-theme, “support for learning retention,” highlights how the impact of the DO-MDD framework’s video segmentation contributed to help students retain programming concepts. Students described how the “bite-size” lessons were a helpful way to learn because it allowed students to not feel “overwhelmed with information” and allowed students to “focus on the subject.” SQStudent 34 shared, “Microlearning lessons are a convenient way for me to learn. They provide focused content that is easy for me to understand and remember. I can quickly grasp specific concepts or skills without feeling overwhelmed.” All three instructors supported this perspective, noting that the segmented videos helped students better retain information and

prepare for assessment. Supporting this perspective, Instructor 03 noted that YouTube Analytics showed students generally viewed the DO-MDD videos around quiz and assignment deadlines where “Most views were generated around that time from Sunday to Tuesday. This is in-line with previous semester trends.” These observations align with Table 16 where a significant number of students (20 out of 29 laptop users) regularly accessed the DO-MDD videos weekly or very often, revealing how students leveraged the microlearning video lessons for targeted review. These findings, along with the IMMS relevance score ($M = 4.19$, $SD = 0.85$) and confidence score ($M = 3.84$, $SD = 0.95$), suggest that students found the shorter video lengths useful for their academic goals and felt that the videos have contributed positively to their learning preparedness.

The strategic use of the DO-MDD videos for quiz and assignment preparation seemed to translate into positive assessment performance, according to instructor reports. Two Instructors observed assessment scores were “quite high,” with average grades showing noticeable increases. Instructor 01 highlighted 60% of students achieved a perfect score, while 30% earned 75%. Instructor 03 also observed favorable outcomes, with assessment averages consistently meeting the 70% metric, where 94% of assessments' average percentages were in the “low 80s and 90s.”

These findings suggest that the DO-MDD framework effectively enhanced student learning. This approach enabled students to utilize microlearning videos for independent review of programming content, and students were able to demonstrate their understanding and application of programming concepts. The instructors' observations of high assessment scores, combined with evidence of frequent video usage, validate the framework's capacity to enhance comprehension and retention. These findings highlight the potential for microlearning approaches to support complex topics like programming.

Summary

This chapter presented the results of this study by focusing on themes that emerged from the data for each of the five research questions. For each question, a set of themes were identified through an analysis of both qualitative and quantitative data. The qualitative data included insights obtained from instructor interviews, instructor journals, student interviews, and open-

ended questions from the online student questionnaire. The quantitative data included IMMS data collected from the online student questionnaire, YouTube Analytics, and student learning data that referred to assignment and quiz results. The findings revealed that instructors found the DO-MDD framework easy to implement and adaptable to their course needs. Additionally, the framework supported flexible, student-centered lesson design, and that students appreciated the short, focused video lessons for their clarity, accessibility, and ability to reduce cognitive overload. However, areas for improvement were also identified, specifically, the need for immediate feedback and greater consistency in video length and structure. Overall, the themes provided a balanced perspective on the DO-MDD framework's strengths and limitations in supporting effective mobile microlearning in higher education programming courses.

CHAPTER 5. DISCUSSION AND CONCLUSIONS

This case study was conducted to understand higher education instructors' and their students' experiences. The purpose of this study was to examine the effectiveness of the Designing for One - Microlearning Design & Development (DO-MDD) framework as a tool for creating microlearning lessons specifically for mobile learning. Although there is existing research focused on mobile interface design, true standards for mobile user interface design have not been established (Gong & Tarasewich, 2004; Li & Luximon, 2020; Ofori & Lockee, 2021; Punchoojit & Hongwarittorn, 2017). Therefore, this study examined five research questions:

1. How did the instructors use the DO-MDD framework?
2. What are the instructors' perceptions of the DO-MDD framework?
3. What are the instructors' perceptions of students' learning using the lessons designed based on the DO-MDD framework?
4. What are students' perceptions of lessons based on the DO-MDD framework?
5. How do lessons based on the DO-MDD framework hinder/enhance student learning?

To address these research questions, this case study employed a fully online approach that involved three higher education instructors and 38 students. Data were collected through Zoom interviews (audio-only), online instructor self-reflection journals, a student online questionnaire, student behavior data obtained from YouTube Analytics, student learning data obtained from instructor reported assignment and quiz results, and researcher-conducted video observations of selected instructor-created microlearning lessons. The purpose behind triangulation was to collect multiple data sources to reinforce reliability and validity, as well as to provide a more thorough and wide-ranging dataset. Member checking was also leveraged to verify accuracy of data and to obtain further clarity from the study's participants about their experiences. Interrater reliability was also applied to ensure consistency of the coding process by two different reviewers. The analysis of the data presented three major findings that addressed the research questions posed in this study: (1) from content overload to student-centered learning, (2) impact of the DO-MDD framework on student performance and engagement, and (3) balancing video length and segmentation in the DO-MDD framework. These findings do not represent or

exhaust all findings, but instead capture profound insights from the data, specifically those relevant to the role of the DO-MDD framework in designing instruction for mobile learning.

The themes revealed advantages and limitations of the DO-MDD framework for designing microlearning lessons for mobile learning, suggesting areas for further consideration. This chapter discusses the findings presented in Chapter 4 within the context of the study's research questions, existing literature, and conceptual framework. The chapter concludes with limitations, implications for policy and practice, future research, and the overall study conclusion.

From Content Overload to Student-Centered Learning

While evaluating the overall effectiveness of the DO-MDD framework, the study also examined instructors' experiences and their perceptions of the framework's impact on lesson design. A common observation among instructors was that the framework shifted their focus from content-heavy lessons to more student-centered learning, prioritizing the programming concepts their students needed to grasp, rather than emphasizing the volume of content required for each lesson. This shift, driven by the framework's flexibility, allowed instructors to tailor both their content and video structure to better align with their students' progress and needs. Instructor 01 commented, "I started with analyzing what my students' needs were from a previous class session in regards to their understanding with coding and if they were comfortable with coding," revealing how the framework encouraged instructors to analyze content taught regarding the specific needs of their students. By reflecting on their students' understanding, instructors made adjustments that better aligned with knowledge gaps, ultimately improving the relevance of each lesson.

This change in focus was enforced by the framework's structure which promoted lessons to be built around a single learning objective (De Gagne et al., 2019; Leong et al., 2021; Shail, 2019), which helped instructors to align their lessons with their students' needs. In Chapter 4, instructors reflected on the flexibility of the DO-MDD framework, which allowed them to adjust their lessons based on students' needs, shifting from content-heavy lessons to focus on specific learning objectives. This approach aligns with student-centered learning principles promoting more engaging and effective instructional strategies. "It made me think about what was most important and try to emphasize those parts," reflected Instructor 03, emphasizing how the DO-

MDD framework helped guide the design of microlearning lessons toward a single learning objective. In line with this approach, De Gagne et al. (2019) found that lessons focused on a single clear topic met students' needs for quick information retrieval. This shift towards a single learning objective aligns with the student-centered principles of mobile learning, where content is focused on the individual needs of students (Traxler, 2010; Traxler, 2016). As Instructor 02 shared:

I used the DO-MDD framework to decide how to break up the material into separate videos. I began by identifying the needs. By identifying what concepts I wanted students to get out of the lesson, I was able to pinpoint a “goal” for each video.

This focus on identifying clear concepts and goals for each microlearning video lesson demonstrates how the framework's structure allowed for targeted instruction. Additionally, the framework's flexible non-linear process enabled instructors to adjust their approach to their students' needs.

The framework's ease of use and non-linear process allowed instructors to make this shift when they designed their microlearning video lessons. As Instructor 01 shared, “you can start in really any phase,” highlighting the framework's flexibility which allowed instructors to adapt lessons based on their ongoing assessments of students' needs. Instructors were able to remain focused on their students' needs as they figured out how to segment the video content into more digestible sections. This shift is reflected in Instructor 02's reflection, “I used the DO-MDD framework to decide how to break up the material into separate videos,” which highlights how the framework encouraged instructors to organize content into manageable lessons. Their experiences showed that the framework's flexibility allowed the instructors to move freely between the DO-MDD phases, rather than following a rigid sequence, reflecting the flexible non-linear foundation of the DO-MDD framework rooted in ADDIE (Artman, 2020; McHugh & McCauley, 2020). For example, Instructor 01 appreciated how “you can start in really any phase” to reflect on “what did not work, and what worked well” to identify adjustments for new lessons. This aspect of the DO-MDD framework's non-linear process is consistent with Artman's (2020) explanation of the ADDIE model's flexibility, where phases such as the evaluation phase can occur at any point of the process. In addition to supporting instructors to tailor their lessons to focus on their students' needs, the framework also had a direct impact on

student outcomes. The next theme discusses the significant impact on the DO-MDD framework on student performance and engagement.

Impact of the DO-MDD Framework on Student Performance and Engagement

In exploring the framework, this study assessed the effectiveness of the DO-MDD framework by examining both the instructors' perceptions regarding their students' learning, and their students' feedback on the microlearning lessons created using the DO-MDD framework. By analyzing these perspectives, the study revealed key insights into the how the framework influenced both the student learning experience and academic performance. Students and instructors reported improvements in focus, engagement, and accessibility, suggesting a more positive learning experience. However, despite generally favorable outcomes, Instructor 03 observed some fluctuations in scores between semesters, possibly due to the timing of the Python unit.

One interesting finding observed by the instructors was a reduction in student burnout, a common issue in programming courses where learning to program can feel overwhelming. By restructuring the programming lessons into shorter manageable lessons, instructors were able to reduce student exhaustion. Instructor 02 shared, "By splitting the material into shorter segments to digest, students are less overwhelmed. This seems to allow students to better understand each concept presented, instead of being inundated with so much information." Research suggests that modifying how information is presented can support in reducing extraneous cognitive load (Alasmari, 2020; Hwang et al., 2019; Sweller et al., 2019). For example, Alasmari (2020) found that modifying information into small chunks helps to limit cognitive strain on learners. This aligns with Instructor 01's experience, who shared that "shorter activities" helped alleviate burnout, a challenge often associated with "whole hour and a half" lessons.

Instructors also noticed a significant drop in questions for specific programming topics from students who would have normally visited during open office hours or would have reached out through email. As Instructor 02 observed, "Just having less people come in for arrays. Kind of a noticeable drop too, because it's one of the hardest, like the second hardest topic of the semester." These results are consistent with past research that found that video microlearning-

designed lessons improved knowledge retention (Boring, 2020; Lee, 2021a; Lee et al., 2021b) and performance (Boring, 2020; Lee 2021a; Lee et al., 2021b; Mohammed et al., 2018; Wang et al., 2021). Specifically, Lee et al. (2021b) found that 80% ($n=28$) of learners scored significantly higher on the posttest, and the pretest guessing rate of 73% fell to 18% on the posttest. Instructor 03 reported similar trends, observing that, “For all assessments, the Average percentage was in the low 80s to mid 90s,” as shown in Tables 8, 9, 10, and 11. This comparative data suggests a positive performance difference associated with the use of the DO-MDD framework. Instructor 01 also noted that 60% ($n=6$) of students achieved a perfect score on a microlearning-aligned quiz. Although this finding is encouraging, no comparative data from previous semesters was available to assess change over time.

While overall student performance improved, Instructor 03 noted performance variability between semesters. This observed variability may be attributed to factors such as the Python unit administered late in the semester, along with the extended length of some programming video lessons, which could have contributed to cognitive overload and student fatigue. Despite this, the average percentage still met the over 70% metric, indicating that students met acceptable performance standards. These results are contrary to previous research that demonstrated significant improvements in exam scores (Abu Farha et al., 2020; Yuda Handaya et al., 2021). The findings suggest that while variability in performance was observed, Instructor 03 noted that there “was a generally favorable outcome” regarding the DO-MDD framework’s impact on student achievement, referring to the fact that, despite some performance variability, the average score still consistently met the over 70% benchmark.

From the students’ perspective, the flexibility and length of the lessons designed with the DO-MDD framework were particularly appreciated. The design of the programming lessons provided students with the flexibility they needed to fit learning into their schedules. Many students expressed how the short, focused lessons fit seamlessly into their busy lives (Lee et al., 2021b). SQStudent 34 shared, “Microlearning offers flexibility and personalized learning, allowing me to choose when to learn.” This reflects the approach taken by Lee et al. (2021b), who designed 5-minute microlearning lessons to fit seamlessly into participants’ schedules, allowing them to complete microlessons “while sitting on the bus or waiting in line to get coffee.” The video lessons also afforded students better control over their learning by allowing

students to pause and rewind the programming lessons, allowing them to revisit material as needed. This feature was highly favored by learners in prior microlearning research, as 80% or more of students expressed satisfaction with the microlearning format (Wang et al., 2021; Zheng, 2021).

The flexibility of the video lessons designed with the DO-MDD framework was further highlighted by Instructor 03, who noted high access rates of programming lessons before assignment and quiz deadlines. “Quizzes were due Mondays and assignments were due Tuesdays. Most views were generated around that time from Sunday to Tuesday,” shared Instructor 03. This observation reflects how students leveraged the flexibility of mobile learning to review content during times that aligned with their individual schedules and academic deadlines.

Separate YouTube Analytics data (see Appendix E, Tables E1 and E2) showed that, across both Spring and Fall 2023, students frequently accessed microlearning videos using computers, interpreted here as laptops, followed by mobile phones and tablets. As laptops are considered mobile devices in this study, the findings align with the mobile learning characteristics that emphasize flexible, anytime and anywhere access to content (Sarrab et al., 2018; Traxler, 2010; Zhampeissova et al., 2020). While some mobile learning research focuses specifically on handheld or pocket-sized devices, the overall use of portable technologies, including laptops, remains consistent with broader definitions of mobile learning. This interpretation supports prior research that indicated that students favored mobile devices, as an effective way to learn (Rifa'i & Sugiman, 2018). More specifically, the students' preference for laptops (76%) was quite high, possibly because larger screens in programming courses allow for more information and can provide a better learning experience (Alasmari, 2020; Söderlund et al., 2019; Sutarno & Kurniawan, 2017; Triyason & Krathu, 2017). This preference is consistent with Söderlund et al. (2019), who found that larger screens led to higher positive emotions. In addition, many students expressed appreciation of the “freedom” and “flexibility” the microlearning lessons provided, allowing them to manage other “responsibilities like jobs and families.” This suggests that the DO-MDD framework offered students a flexible (Churchill & Churchill, 2008; Dennen & Hao, 2014; Sarrab et al., 2018; Sharples, 2000; Vavoula & Sharples, 2009; Traxler, 2018) and accessible (Sarrab et al., 2018; Traxler, 2010; Zhampeissova et al.,

2020) learning experience that suited their busy schedules (Hanshaw & Hanson, 2018; Stratton et al., 2020) when they prepared for assessments. Although the framework's flexibility and accessibility offered many advantages, both instructors and students provided critical feedback regarding challenges about video length. The final theme will explore the challenges of finding the optimal balance between video length and ensuring that content is adequately segmented when creating microlearning video lessons with the DO-MDD framework.

Balancing Video Length and Segmentation in the DO-MDD Framework

The final theme that emerged from the study explored challenges related to video length. While instructors found the DO-MDD framework easy to implement in designing microlearning programming lessons, condensing some of the programming topics into shorter lessons was challenging. The framework's suggestion to keep videos short sometimes conflicted with the depth required for certain complex topics. As SQStudent 02 pointed out, videos longer than 15 minutes were too lengthy, and it felt like the "content is dragging," which diminished the benefits of bite-sized learning. Without strict guidelines, instructors wondered if the length of their microlearning video lessons were appropriate. This led to instances where some of the video lessons did not adhere to the short video format. This challenge corresponded with feedback from some students who commented about the lengthiness of some of the microlearning video lessons.

A few students felt videos that exceeded 30 minutes were too long to maintain their attention. As suggested by research (De Gagne et al., 2019; Diaz Redondo et al., 2020; Dolasinski & Reynolds, 2020; Hug, 2007; Jahnke et al., 2020; Leong et al., 2021;), the preference among students was for the microlearning videos to not exceed 15 minutes (De Gagne et al., 2019; Diaz Redondo et al., 2020; Leong et al., 2021), as shorter videos kept their focus and was easier to integrate into their schedules (Hanshaw & Hanson, 2018; Stratton et al., 2020). Student 06 shared that videos longer than 15 minutes often require them to "skip through it and try to find important part." Student 06 further emphasized that shorter videos set a "precedent that everything is important." This issue with video length is tied to the broader principle of cognitive load theory, suggesting that shorter, focused lessons can reduce extraneous cognitive load (Alasmari, 2020; Hwang et al., 2019; Sweller et al., 2019) and avoid overwhelming students

with excess information (Almasseri & AlHojailan, 2019; Beukes, 2019; Mayer, 2008, 2021a, 2021b). Many students appreciated how the focused lessons helped them to avoid learning “everything at once,” which made it “easier to absorb the information” and prevented them from being “overwhelmed with information.” This approach is supported by Mayer’s (2021a) research, where breaking lessons into smaller, manageable segments helped to reduce cognitive load and improved learner performance.

The process of segmenting content effectively plays a significant role in student learning. Instructor 03 explained that when designing the microlearning video lessons with the DO-MDD framework, the primary focus was “how to split up the videos, making sure that what I cover in the video, in the original video was still maintained in the smaller videos.” This approach aligns with research indicating that properly segmented content can enhance retention and understanding (Alqarni, 2020; Lee, 2021a; Lee et al., 2021b; Mohammed et al., 2018; Wang et al., 2021). For example, Mohammed et al. (2018) found that after week 6, the microlearning group had an exam passing rate of 82%, while the traditional learning group had a passing rate of 64%. Additionally, the microlearning group had zero failures. Similarly, Alqarni (2020) found that learners in the microlearning group, who were provided with programming content in separate short videos, were better able to master more programming skills compared to those who learned with traditional lessons.

Proper segmentation also helps reduce cognitive load (Alasmari, 2020; Sweller et al., 2019; Curum & Khedo, 2021; Mayer, 2024; Wang et al., 2021), particularly when instructional content is condensed into shorter lessons, enabling students to focus on individual learning objectives (Sweller et al., 2019; Wang et al., 2021). Supporting the benefits of segmentation, Instructor 02 shared, “By splitting the material into shorter segments to digest, students are less overwhelmed. This seems to allow students to better understand each concept presented, instead of being inundated with so much information.” This quote reflects how effective segmentation helps students focus on one learning objective at a time, minimizing cognitive load. In line with Instructor 02’s observation, SQStudent 34 noted that microlearning lessons “provide focused content that is easy for me to understand and remember,” enabling them to “quickly grasp specific concepts or skills without feeling overwhelmed.” This further supports the idea that shorter, segmented lessons improve focus and reduce cognitive load.

While the assessment data were somewhat limited and varied across instructors, there were several indicators that well-structured, segmented video lessons may have supported student performance. Instructor 02 shared, “The average grades for the quiz and assessments were higher,” and Instructor 03 observed that students’ average scores ranged from the low 80s to mid 90s. Instructor 01 found that 60% ($n=6$) of students achieved a perfect score, further indicating that appropriate segmentation of lessons through the DO-MDD framework is important for microlearning development and improving learning outcomes. These results align with those of Wang et al. (2021), who found that microlearning videos focused on single topic learning objectives had a positive impact on student performance. Specifically, over 80% of students who learned with the 5–7-minute microlearning videos scored 80% or higher on the exam.

Connection to the Conceptual Framework

This study was structured around a conceptual framework that shaped the research questions and methodology. Due to the limited research on microlearning design frameworks and gap in the literature related to a defined set of empirically researched mobile learning design principles, this study integrated ADDIE, the Four Instructional Flow (Jahnke et al., 2020), and the Microlearning Model (Dolasinski & Reynolds, 2020) to propose a new conceptual framework. ADDIE, a prevalent model in instructional design (Budoya et al., 2019; Yeh & Tseng, 2019), was used as a base to provide instructors with distinct phases that they could navigate when creating microlearning lessons on their own, and the Four Instructional Flow (Jahnke et al., 2020), and the Microlearning Model (Dolasinski & Reynolds, 2020) were used to provide guidelines for creating microlearning lessons for mobile learning.

The non-linear structure of ADDIE allowed the instructors to independently design their microlearning lessons based on their students’ needs instead of following a linear process, and the Dolasinski and Reynolds’s (2020) Microlearning Model helped instructors to focus their video lessons to a single objective which students highly appreciated. However, given the challenges instructors struggled with having the flexibility to adjust video lengths and the feedback from students who felt videos that exceeded 15 minutes were too long, it might be beneficial to reevaluate if the 15-minute limit should be a flexible suggestion or definitive

standard. Defining an exact time limit may help to maintain student interest and align lessons with principles of the Microlearning Model (Dolasinski & Reynolds, 2020) that can avoid the strain of cognitive load (Cabañero et al., 2019; Curum & Khedo, 2021; Hwang et al., 2019).

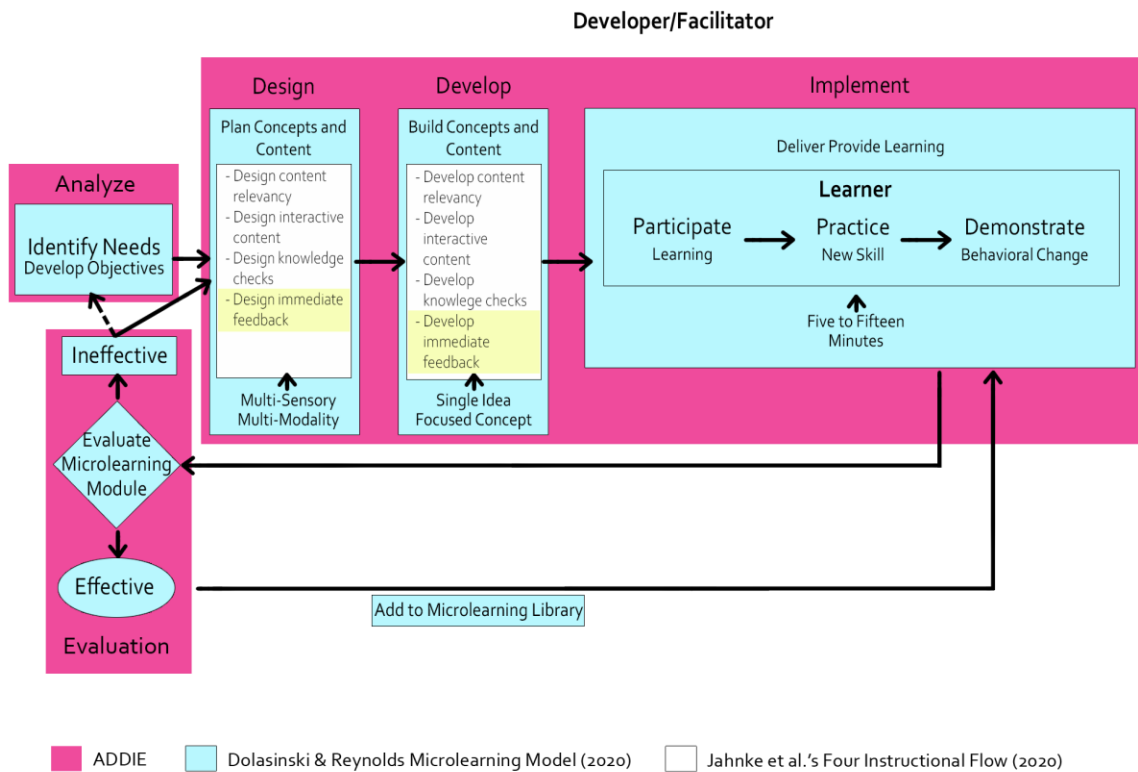
To further contextualize how the DO-MDD framework was applied in practice, the researcher conducted an observational review of selected microlearning video lessons (see Appendix F, Table F1) created by Instructor 03. The observed videos consistently focused on a single learning objective and included relevant examples, with some prompting learners to pause and reflect. In several cases, videos that exceeded the 15 minute guideline did so due to extended hands-on programming walkthroughs, often ranging from 10 to 20 minutes. However, the core instructional content remained within the recommended time limit. These walkthroughs served as a practical extension of the lesson.

Although the instructors found Jahnke et al.'s (2020) Four Instructional Flow components easy to implement, providing immediate feedback in asynchronous lessons presented a challenge. This challenge was highlighted by Student 06, who expressed a clear need for immediate feedback, stating, "The challenge is...there's not really real time feedback...you still have to go and message your professor." Given this feedback, incorporating strategies for providing instant feedback into asynchronous microlearning video lessons could significantly improve student engagement. Previous research supports this suggestion, demonstrating that both immediate and delayed feedback contribute to improving knowledge retention (Al Hakim et al., 2022; Fyfe et al., 2021; Hathila et al., 2023; Lu et al., 2023; Ryan et al., 2024; Van Ginkel et al., 2020), motivation (Al Hakim et al., 2022), and confidence (Hathila et al., 2023). For example, Ryan et al. (2024) observed that immediate feedback led to a 69% increase in scores on the same day, and a 67% increase after one week. Building on the student feedback and research, integrating immediate feedback into the DO-MDD framework would meet students' need for timely feedback and provide the support they need to succeed. The modification to the framework involves specifying immediate feedback as a design component in the Design phase and a develop component in the Develop phase as shown in yellow in Figure 4. In practice, this can be supported through tools such as Canvas Studio Video Quizzes and H5P, which allow instructors to embed interactive questions and provide immediate feedback within microlearning video lessons. These tools offer practical solutions for the challenges identified in this study by

helping instructors embed timely feedback directly into video-based lessons, directly supporting students' need for immediate feedback.

Figure 4

Modified Designing for One - Microlearning Design & Development (DO-MDD) Framework



Note: Integrated microlearning design framework based on ADDIE, Dolasinski and Reynolds's (2020) Microlearning Model, and Jahnke et al.'s (2020) Four Instructional Flow, with modifications to include immediate feedback incorporated into the Design and Development phases.

Limitations

Although this study provided valuable insights, several limitations affect the generalizability to the larger population. One notable limitation was the variation in data

collection periods, where one instructor provided data over two semesters due to insufficient participation during the first semester, while the other two instructors contributed data from one semester each. This may have affected the consistency of the data. To mitigate this, efforts were made to gather the instructors' experiences for each semester through self-reflective journals, semi-structured interviews, and member checking. Another limitation involved the unregulated nature of the instructors' self-reflective journal entries. In some cases, delays in recording reflections may have influenced their recollection of events if there was a lapse in time from the recorded occurrence. Additionally, the varying number of microlearning videos created by each instructor might have influenced their experience with the DO-MDD framework. The study may have also been impacted by participant bias. The Hawthorne Effect (Levitt & List, 2011) could have influenced student responses, as students may have wanted to present themselves in a favorable light. Moreover, the presence of Amazon eGift card incentives offered to students may have resulted in biased responses (Abdelazeem et al., 2023; Stanley et al., 2020), where some students may have merely participated for the eGift card, potentially influencing the quality of their responses. However, the incentives were kept relatively low at \$5 and \$10 to reduce participation bias, as higher valued incentives might have skewed the motivations of students to participate (Jia et al., 2021; Sataloff & Vontela, 2021; Stanley et al., 2020). Furthermore, one instructor had only taught in face-to-face settings, which may have resulted in an imbalance in perspectives. Even though the instructor's experience was limited to in-person instruction, the instructor still saw how the DO-MDD framework was applicable to improving classroom engagement in face-to-face classes, demonstrating the framework's versatility. Finally, the limited number of programming instructors and students who participated in the study limits the generalizability of the findings. The results may not be representative of the general higher education population. Additionally, a larger data set could uncover significant variations in instructors' implementation of the DO-MDD framework, providing a richer understanding of its overall impact.

Implications for Theories and Practice

The findings from this study highlighted several implications for theories and instructional practice, specifically for designing and implementing microlearning lessons in education. One of

the key findings from this study was the value of focusing each lesson on a single learning objective (De Gagne et al., 2019; Dolasinski & Reynolds, 2020; Dolasinski & Reynolds, 2021; Jahnke et al., 2020; Leong et al., 2021; Shail, 2019). The results showed overall improvement in student performance with many students emphasizing the appreciation of the convenience of the short video lessons and how it was effective in keeping their focus (Hanshaw & Hanson, 2018; Stratton et al., 2020). While most of the microlearning video lessons were considered short in length, videos that exceeded 15 minutes were noticeable by the students who voiced their dissatisfaction with the extended length. Students emphasized the importance of keeping lessons to 15 minutes or less to maintain their attention (De Gagne et al., 2019; Diaz Redondo et al., 2020; Leong et al., 2021). Rather than providing video length as a suggestion, setting the maximum length of 15 minutes as a clear standard may help instructors to design more effective video lessons that avoid overwhelming students with excess information (Almasseri & AlHojailan, 2019; Beukes, 2019; Mayer, 2008, 2021a, 2021b) and that align with principles of the Dolasinski and Reynolds's (2020) Microlearning Model. Even after the study concluded, one instructor continues to use the DO-MDD framework in their in-person classes, demonstrating the framework's practical value and adaptability. The researcher also actively incorporates the framework and related strategies in her current professional role, applying its principles to guide faculty training efforts and further reinforce its real-world application. These examples point to the framework's potential for sustained use and future growth in educational settings. Its clarity and structure made it usable to instructors with limited instructional design training, allowing them to independently develop microlearning lessons with minimal support. This suggests that the DO-MDD framework can serve as a practical, easy-to-follow guide for instructors across diverse contexts and is well-suited for broader implementation in teaching practice.

Another significant implication relates to the integration of immediate feedback for asynchronous learning. Although Jahnke et al.'s (2020) Four Instructional Flow was easily implemented, providing immediate feedback in an asynchronous video lesson proved difficult. Students expressed a desire for real-time feedback to enhance their experience while learning programming. To meet this need, instructors should integrate immediate feedback into the design and development of microlearning video lessons, as proposed in the modified DO-MDD framework, to improve the learning experience. As previously discussed, tools such as Canvas

Studio video quizzes and H5P can help embed immediate feedback directly within microlearning video lesson. Not only could these strategies lead to higher scores (Fyfe et al., 2021; Lu et al., 2023; Ryan et al., 2024), but it could also reduce cognitive overload by delivering feedback in manageable chunks (Lu et al., 2023). These findings emphasize that while immediate feedback was challenging to implement, students clearly expressed a strong desire for it. As instructors continue to design asynchronous microlearning lessons, the integration of interactive tools that offer real-time or just-in-time feedback should be considered essential. Tools like H5P and Canvas Studio video quizzes can serve as models for implementing these features, but additional research is needed to determine how best to align feedback strategies with lesson development guided by the DO-MDD framework.

The study also revealed that one instructor engaged in continuous self-reflection throughout the process of creation and implementation of the microlearning video lessons. This observation aligns with research emphasizing the value of reflection effective teaching and instructional design (Mumford & Dikilitaş, 2020). While this ongoing reflection was beneficial, this suggests a gap in the current DO-MDD framework, which does not include a distinct phase for reflection. Introducing a distinct “Reflection” phase could provide instructors with a structured space to assess their design and teaching strategies, as well as their students’ learning, promoting critical reflection on both their content knowledge and lesson design, a practice that Mumford and Dikilitaş (2020) identified as a crucial phase to effective teaching. Adding this phase could promote a structured, iterative review process that strengthens the framework’s adaptability and effectiveness, providing instructors with more meaningful insights into both their teaching and student learning outcomes (Gorski & Dalton, 2020; Mumford & Dikilitaş, 2020).

Recommendations for Future Research

The goal of this study was to explore the effectiveness of the DO-MDD framework as a tool for designing microlearning lessons for mobile learning, based on the experiences and perceptions of the instructors and their students. While the study provided valuable insights into using the DO-MDD framework for designing microlearning video lessons, several areas have emerged that could have implications for future research.

First, replication of this study with more participants across different disciplines over the same length of period would reveal findings that are applicable to a wider range of educational disciplines. Additionally, a larger data set would help uncover a more detailed exploration of the differences between how instructors implement the DO-MDD framework, offering valuable insights into its adaptability across different learning environments. Expanding the study across a variety of subject areas, such as social sciences, natural sciences, and humanities, could determine if the results of this study are generalizable to other educational disciplines. Additionally, conducting the study over an extended time frame could reveal trends in student engagement and performance, providing valuable insights for a more comprehensive assessment of the DO-MDD framework's effectiveness.

Another recommendation for future research is to compare the application of the DO-MDD framework in both face-to-face and online teaching environments. Investigating how the development of microlearning lessons is influenced by different instructional formats could provide critical insights on the framework's versatility. For instance, it would be beneficial to understand how synchronous face-to-face interactions compare with asynchronous online learning environments in terms of their impact on the effectiveness of microlearning-designed lessons. This comparison could provide insights into which features of the DO-MDD framework are more effective in a particular instructional setting, helping to refine the framework for broader use.

Finally, assessing the effectiveness of the modified DO-MDD framework with immediate feedback strategies could provide valuable insights for future research in microlearning. The addition of immediate feedback represents an important modification, as student feedback emphasized the need for real-time support during the microlearning lessons. Future research could explore how incorporating immediate feedback into the framework affects student performance in programming courses and other subject areas. Specifically, research should focus on how immediate feedback influences knowledge retention, motivation, and satisfaction. Such research would provide valuable insights into whether immediate feedback is an essential element of the framework's effectiveness in optimizing student engagement and better learning outcomes.

Conclusion and Summary

In today's fast-paced world, where students rely on mobile devices for the convenience of learning anytime, anywhere (Diaz Redondo et al., 2020; Hanshaw & Hanson, 2018; Lee et al., 2021b; Shail, 2019), mobile learning becomes a popular method for learning. This study was conducted to understand higher education instructors' and their students' experiences. The purpose of this study was to explore the effectiveness of the DO-MDD framework as a tool for creating microlearning lessons specifically for mobile learning. While the DO-MDD framework was largely effective, it also served as a vessel for broader questions and further inquiry, specifically regarding the integration of immediate feedback into the framework.

What emerged from the study was a deeper understanding of how instructors and students interacted with the framework in a real-world setting. Instructors and students found value in the DO-MDD framework, particularly in it streamlined lessons to focus on a single learning objective and, in turn, helped to maintain student engagement and focus. However, the study also revealed challenges, such as the importance of standardized video lengths for microlearning lessons to sustain students' attention and the desire for immediate feedback to enhance the learning experience. These limitations suggest there is a need for future research to explore how the modified DO-MDD framework, with immediate feedback strategies, can be applied across different teaching formats to optimize learning. Additionally, the design of effective instructional videos remains an important area for continued research, as educators seek to refine best practices for delivering microlearning lessons through video.

Beyond the broader findings, one of the most meaningful outcomes of this study was seeing how the DO-MDD framework empowered instructors to make instructional decisions based on their students' needs. While other instructional design models could be applied to mobile learning, instructors found the DO-MDD framework both easy to use and flexible enough to adapt to the design of their programming lessons. It served not only as a design model, but also as a practical guide that supported intentional, student-centered design choices.

During implementation, one surprising finding was that many students reported primarily accessing the microlearning video lessons on laptops rather than on smaller mobile devices such as tablets or smartphones. Despite this, students still found the lessons effective and appreciated

their clarity, convenience, and focus. This suggests that well-designed microlearning is not limited to mobile delivery and can be effective across a range of devices.

As microlearning continues to gain traction in higher education, these findings contribute to the growing body of literature on microlearning and mobile learning design, highlighting the adaptability of the DO-MDD framework across both instructional formats and devices. The framework's ability to capture students' attention, deliver relevant content, build confidence, and promote satisfaction, as reflected in the students' feedback and IMMS scores, aligns with the elements of the ARCS model, ultimately helping to sustain student engagement. As William Butler Yeats eloquently stated, "Education is not the filling of a pail, but the lighting of a fire," reflecting the purpose of the DO-MDD framework in creating impactful, engaging learning experiences that ignite learners' motivation and support meaningful learning.

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APPENDIX A

Instructor Interview Protocol

Introduction:

Hello [Name of participant],

Thank you for taking the time to speak with me today. Your feedback is very valuable and will help shed light the possible effectiveness of microlearning designed lessons in higher education.

This interview should take no more than one hour. As my email mentioned, you should be in a location that is quiet enough for us to speak and that has a stable Internet connection. I am in no way testing you, or your knowledge. I just want to get your honest views, so please feel free to speak candidly. There are no right or wrong answers.

Please know that your participation is voluntary and should be of no or low risk to you, however, if you feel uncomfortable at any point you want to stop the interview, you can do so without any negative consequence to you. Is that ok with you?

Participant: [YES]

While we are able to see each other by video, to help with a more natural conversation, I will not be recording the video image during this session. I will, however, be recording the audio. The audio recording will serve to help me capture your thoughts and will help me with my analysis for this study. As previously mentioned, all references to your actual name will be removed and a pseudonym (fake name) will be used in its place. You had previously signed the consent form agreeing to be audio recorded. Do you still grant me permission to capture an audio recording of this session?

Participant: [YES]

Great. Now I will be asking you questions about your experiences with the designing and implementing the python video lessons.

Interview Questions

1. How did the DO-MDD framework guide in the development of microlearning lessons?
 - a. How was the process of getting started with the DO-MDD framework
 - b. What are your perceptions of using the DO-MDD framework?
 - c. Were there specific aspects of the framework that were difficult to integrate into the design and development of the microlearning videos?
 - d. Were there specific aspects of the framework that were easy to integrate into the design and development of the microlearning videos?

- e. How often did you return to the DO-MDD?
2. Could you share your experiences using the DO-MDD framework?
 - a. Have you previously designed and developed lessons that similarly followed the design and development of microlearning lessons using the DO-MDD framework?
 - b. How was your experience using the DO-MDD framework when designing video lessons for the python unit?
3. Could you share some of the challenges you may have faced when using the DO-MDD framework when you designed python video lessons?
 - a. What are some of the areas that could be improved?
4. Could you share some of the aspects you liked about the DO-MDD framework?
5. How was your overall experience using the DO-MDD framework when you designed python video lessons?
 - a. How was this experience compared to recording a traditional lecture video?
6. What were some of the observations of your students? Observations may include communication with students, student behavior (YouTube analytics), and student learning data (results from quizzes, homework, and tests).
 - a. What were some of the observed challenges that your students experienced?
 - b. What were some of the observed successes that your students experienced?
 - c. Were there any significant observations obtained from the click analytics?
 - d. Were there any significant observations from student learning data (results from quizzes, homework, tests)?

Wrap Up

Thank you for your time and participation in this interview today. Your input is truly valuable. Would it be ok if I were to contact you after I have completed interpreting the results, in order to validate the findings with you? I will send you an email to schedule a brief Zoom session, closer to that time, where I will go over the findings and interpretations.

APPENDIX B

Online Student Questionnaire

The survey will consist of 40 questions. The first 36 questions are short statements, each with a 5-point scale from “Strongly Agree” to “Strongly Disagree” in a radio button format, followed by four open-ended questions.

Statements with a 5-point scale from “Strongly Agree” to “Strongly Disagree”

1. The python lessons seemed interesting at the beginning and got my attention.
2. The python lessons are eye-catching.
3. The explanation of the learning content helped to hold my attention.
4. The python lessons were very abstract that it was hard to keep my attention on them.
5. The python lessons looked dry and unappealing.
6. The way information was presented in the python lessons helped keep my attention.
7. The python lessons stimulated my curiosity.
8. The amount of repetition in the python lessons caused me to get bored sometimes.
9. I learned some things that were surprising or unexpected in the python lessons.
10. The python lessons helped keep my attention with various explanations.
11. The python lessons were boring.
12. The python lessons were wordy, which was irritating.
13. It is clear to me how the content of the python lessons is related to things I already know.
14. There were a variety of examples in the python lessons that showed me how the material could be important to some people.
15. Completing the python lessons successfully was important to me.
16. The content in the python lessons is relevant to my interests.
17. There were explanations or examples of how people use the knowledge in this lesson.
18. The python lessons conveyed an impression that the content is worth knowing.
19. The python lessons were not relevant to my needs because I already knew most of it.
20. I was able to relate the content of the python lesson to things that I have seen, done, or thought about in my own life.
21. The content of the python lessons will be helpful to me.

22. When I first looked at the python lessons, I had the impression that it would be easy to learn from.
23. The python material was more difficult to understand than I would like for it to be.
24. After receiving an explanation about microlearning designed lessons, I felt confident that I could learn from microlearning designed lessons.
25. There was too much information in the python lessons that it was hard to pick out and remember the important points.
26. When I used the python lessons, I was confident that I could learn the content.
27. The exercises in the python lessons were too difficult.
28. After completing the python lessons, I was confident that I would be able to pass a test on the content.
29. I could not really understand quite a bit of the content in the python lessons.
30. The good organization of the python lessons helped me be confident that I would learn the material.
31. Completing the python lessons gave me a satisfying feeling of accomplishment.
32. I enjoyed the python lessons so much that I would like to know more about this field.
33. I really enjoyed studying with microlearning designed video lessons.
34. The feedback after the exercises, or other comments in the python lessons, helped me feel rewarded for my efforts.
35. It felt good to successfully complete the python lessons.
36. The python lessons were well-designed, and I was glad that I was able to learn with them.

Open-ended questions

37. How often did you use the python videos?
38. Which type of technology did you most frequently use to view the python videos with?
[Mobile Phone, Tablet or iPad, Laptop, Desktop]
39. What are your thoughts on microlearning designed lessons?
40. Can we contact you to get a little more details about your experience using the microlearning designed lessons? If yes, please share your email address.

APPENDIX C

Student Interview Protocol

Introduction:

Hello [Name of participant],

Thank you for taking the time to speak with me today. Your feedback is very valuable and will help shed light the possible effectiveness of microlearning designed lessons in higher education.

This interview should take no more than one hour. As my email mentioned, you should be in a location that is quiet enough for us to speak and that has a stable Internet connection. I am in no way testing you, or your knowledge. I just want to get your honest views, so please feel free to speak candidly. There are no right or wrong answers.

Please know that your participation is voluntary and should be of no or low risk to you, however, if you feel uncomfortable at any point you want to stop the interview, you can do so without any negative consequence to you. Is that ok with you?

Participant: [YES]

While we are able to see each other by video, to help with a more natural conversation, I will not be recording the video image during this session. I will, however, be recording the audio. The audio recording will serve to help me capture your thoughts and will help me with my analysis for this study. As previously mentioned, all references to your actual name will be removed and a pseudonym (fake name) will be used in its place. You had previously signed the consent form agreeing to be audio recorded. Do you still grant me permission to capture an audio recording of this session?

Participant: [YES]

Great. Part of the reason you are here is that your instructor and I wanted to learn more about microlearning designed lessons. So, your instructor designed the python unit videos using a microlearning design. As a brief reminder, microlearning designed lessons are different from traditional lecture lessons in that a microlearning designed lesson will break up a single lecture into smaller separate lessons by topic. Now I will be asking you questions about your experiences with the python video lessons.

Interview Questions

1. Could you please share about your experiences using the python video lessons?
 - a. Have you previously taken courses that used a similar format as the python lessons?

- b. How was your experience using video lessons for the python unit?
 - c. Did you think the lessons were different from other lecture recordings? How did it feel different from other formats?
2. Could you share some of the challenges you may have faced using the python video lessons?
 - a. What are some of the areas that could be improved?
 - b. Were there any other challenges related to accessing the content?
 - c. Did this experience meet your expectations?
 - d. What is your previous experience in this type of environment?
3. Could you share some of the aspects you may have liked when you used the python video lessons?
 - a. What do you think about the design of the python video content?
 - b. Is there a specific python video that you liked?
 - c. Did this type of python video lesson influence your desire to continue learning?
 - d. Were there specific aspects of the python video that caught your attention?
 - e. Were there specific aspects of the python video that made the content relevant or not relevant?
 - f. Were there aspects of the video that helped to build confidence in your python scripting?
 - g. Were there aspects of the video that provided a sense of satisfaction after completion of the python video lessons?
4. Was there a specific technology that you preferred to use when learning with the python video lessons?
 - a. Why did you use this and not a mobile device?
5. How was your overall learning experience using the python video lessons?

Wrap Up

Thank you for your time and participation in this interview today. Your input is truly valuable. Would it be ok if I were to contact you after I have completed interpreting the results, in order to validate the findings with you? I will send you an email to schedule a brief Zoom session, closer to that time, where I will go over the findings and interpretations.

APPENDIX D

Quotes Supporting Theme Analysis

Appendix D presents verbatim quotes organized by themes and sub-themes discussed in Chapter 4. These quotes were obtained from instructor interviews, instructor journals, student interviews, and open-ended responses in the student online questionnaire. While select quotes are integrated into the main text, these tables provide the complete collection of quotes relevant to the identified themes.

Table D1

Themes Reflecting Instructors' Use of the DO-MDD Framework in Microlearning Video Design (Research Question 1)

Theme	Category	Participant Code	Coded Excerpts
Student-Centered Content analysis	Assessed students' needs	Instructor 01	“Before creating the microlearning lesson, I started with analyzing what my students’ needs were from a previous class session in regards to their understanding with coding and if they were comfortable with coding.”
		Instructor 02	“Recognizing what the students' needs are.”
		Instructor 03	“It made me think about what was most important and try to emphasize those parts.”
	Identified break points	Instructor 02	“I tried to split it up into kind of like the main content, like the different parts.”
Instructor 02		“I used the DO-MDD framework to decide how to break up the material into separate videos.”	

Theme	Category	Participant Code	Coded Excerpts
		Instructor 03	“The main focus was the conversion of the lecture video portion of the curriculum into a series of microlearning lessons.”
		Instructor 03	“Some lessons were easier to convert to microlearning lessons than others. The easiest lecture to convert was the lecture Program Arguments, Exceptions, Regex, due to the clearly distinct topics in that lecture.”
		Instructor 03	“So in terms of making sure that there are activities to ensure that that are in line with the videos, I mean, that was already in place. My main focus was how to split up the videos, making sure that what I cover in the video, in the original video was still maintained in the smaller videos because some of the questions that I ask on the quiz or some of the things that I asked them to do for an assignment are directly in line with the video.”
		Instructor 03	“So my main focus was to ensure that when I did break up the video, it still maintained the original essence, but it allowed me to update some of the slides and some of the examples.”
Framework-driven adaptation	Student-centered design	Instructor 01	“During the design and development of the lesson, based on the students' understanding and comfortability with coding, these items determined how much explanation I needed to do on concepts and code, how much interaction (back-and-forth) I will have with the students, and how much coding items of the topic I will cover.”
		Instructor 02	“I used the DO-MDD framework to decide how to break up the material into separate videos. I began by identifying the needs. By

Theme	Category	Participant Code	Coded Excerpts
			identifying what concepts I wanted students to get out of the lesson, I was able to pinpoint a “goal” for each video. The goals were what I centered the design and development steps around.”
	Engagement focused	Instructor 01	“They did a quiz at the end of the microlearning lesson.”
		Instructor 02	“With programming, I feel the most useful/effective way to learn is to simply write code.”
		Instructor 03	“The secondary focus was ensuring the multi-sensory/multi-modality aspect of the framework.”
		Instructor 03	“Following along with the code demonstration provides students with “hands-on” practice. To ensure students internalized the concepts of the lectures, there was a weekly quiz and weekly programming assignment. The weekly quiz consisted of five to seven open response questions.”
		Instructor 03	“The weekly programming assignment involves the student incorporating concepts that were presented during the week to create a program. In most cases, students create a program from scratch, in other cases, students are provided starter code that is to be modified based on specifications of the program. For example, one assignment involves students creating a Python program that reads in a text file of potential credit card numbers and categorizes them based on the card network. In another assignment, students define functions that mimic a grocery list.”

Theme	Category	Participant Code	Coded Excerpts
Continuous reflection and iteration	Instructor 01	“I think I started on the analysis part first and then worked my way to the design, then the development, then the implementation. And then I believe there's kind of like a reflection phase of it. And then back to the analysis part of it. So I think I went in that order a bit.”	
	Instructor 01	“At the ending of the day, I reflect and write down on my personal syllabus that is not shared with the class on what we covered, what did not work, and what worked well. Then analyze the needs to continue with the lesson, revisit a previous lesson, or adjust and adapt my new lesson from what I learned in my previous class session.”	
	Instructor 02	“I think honestly, going about it by, you know, to like identify the needs... that’s something I didn’t purposely think about... I was thinking about it on my end as opposed to recognizing what the student’s needs are.”	
	Instructor 03	“In the analysis phase of the DO-MDD framework, it is always a good idea to take stock and ensure that the lessons that are being created are in line with the learning objectives. Since concepts are separated, it allows for new material to be added in the future.”	
	Instructor 03	“Determining how much content to be in a video while balancing the length and the amount of videos was challenging... The approach that was taken was a mixed approach... based on the amount of videos that would result... and/or if it made more sense to bundle concepts.”	

Table D2

Themes Reflecting the Instructors' Experience with the DO-MDD Framework (Research Question 2)

Theme	Category	Participant Code	Coded Excerpts
Framework usability	Ease of use	Instructor 01	“Pretty easy to follow.”
		Instructor 02	“I was thinking about it on my end as opposed to recognizing what the student's needs are. So I think that step was actually really helpful, especially in thinking about how to break up the video with videos.”
		Instructor 03	“It was pretty straight forward.”
		Instructor 03	“It wasn't too bad.”
	Adaptability	Instructor 01	“What's nice is that...it's like a cycle, so you can start in really any phase.”
		Instructor 03	“So by breaking it up into specific concepts or even a sub concept, I would imagine that it be easier to update in the future moving forward.”
		Instructor 03	“But because of the way that it's split, I mean, it would not be a big issue if I had to rerecord.”
		Instructor 03	“Since concepts are separated, it allows for new material to be added in the future. This is especially helpful in the technology field where things are always changing.”
Design concerns	Content organization	Instructor 01	“The challenges for designing included what concepts, what are items I need to emphasize or explain further to anticipate questions that I

Theme	Category	Participant Code	Coded Excerpts
			won't be doing as the microlearning video is playing."
		Instructor 01	"The only one I felt that was kind of enough detailed was like the analysis and then the reflection. Yeah, and implementation was pretty specific too. Yeah, but I feel like the design and development part, it felt a little empty. It didn't kind of give me what I was hoping to see."
		Instructor 03	"My concern was they will have to manage which videos they watched and which they didn't."
		Instructor 03	"I cannot guarantee that the students will watch videos in succession."
		Instructor 03	"So one of the challenges was how am I going to layout each video on a web page for students to watch?"
		Instructor 03	"Determining how much content to be in a video while balancing length and the amount of videos was challenging."
	Video length & structure	Instructor 02	"I think it's always kind of hard to think about is this too short?"
		Instructor 03	"The length. But that was also a challenge. You know how to break up the video. At what point. Some videos were easier."
		Instructor 03	"Difficulty with knowing when to break it up and then if I had to think about the total length, then that would have just been something more that I had to worry about."
		Instructor 03	"So that was still kind of a challenge for me is like, what is a good time length?"

Theme	Category	Participant Code	Coded Excerpts
Teaching effectiveness	Instructional efficacy	Instructor 02	“Trying to design multi-sensory/multi-modality content was a little challenging due to the content. With programming, I feel the most useful/effective way to learn is to simply write code. So, it was a little challenging to think of other activities for the students to do.”
		Instructor 03	“Additionally, some concepts do not make too much sense on their own.”
		Instructor 03	“It was difficult to determine if each concept should be given its own video or if it would be acceptable to group certain concepts together in the same video.”
	Avoided burnout	Instructor 01	“I never did microlearning lessons, so it helped me understand and reflect on where students could burn out while learning about code.”
		Instructor 01	“Microlearning, I think is really helping in at least the framework and what I've been using it in regards to the big ideas from it, you know, giving the students short, I guess shorter activities instead of just doing a whole hour and a half where they just get burnt out, exhausted, and then when they come back to me, they don't have that positive feeling.”
		Instructor 02	“By splitting the material into shorter segments to digest, students are less overwhelmed. This seems to allow students to better understand each concept presented, instead of being inundated with so much information.”
Framework impact	Positive feelings	Instructor 01	“I really like the idea of microlearning and I incorporated it as part of my implementation of my class lesson.”

Theme	Category	Participant Code	Coded Excerpts
		Instructor 02	“I think that was, the most helpful part about doing it this way.”
		Instructor 03	“I like the idea of the shorter videos.”
		Instructor 03	“I think it ran smoothly.”
		Instructor 03	“It is helpful and it’s less of a decision. If you want to update like a 15 minute video versus an hour lecture.”
		Instructor 03	“The initial creation of the microlearning videos overall is a much more manageable process than recording, editing, and producing an hour long lecture.”
		Instructor 03	“From a computer resource perspective, resting, editing, and producing microlearning lessons has less strain on the system overall than compared to an hour long lesson. There were times when my computer started to lag while editing an hour long video.”
	Critical reflections	Instructor 01	“I’m truthfully not a big fan of doing videos.”
		Instructor 01	“I feel this is double work and takes up a lot of my time.”
		Instructor 03	“It was a challenge to split the lecture while maintaining the essence of the existing lectures. An initial approach was to break up the lecture into two pieces between the lecture and demonstration. However, that did not resonate with the idea of “micro” in microlearning.”

Table D3

Themes Reflecting Instructors' Perceptions of Student Learning with the DO-MDD Framework (Research Question 3)

Theme	Category	Participant Code	Coded Excerpts
Student Satisfaction	Favored structure	Instructor 02	"I did have two students comments on it, mentioning that they, they do like that it's broken up."
		Instructor 02	"Students prefer the shorter videos!...But after spitting the material into more manageable chunks, I didn't receive any more complaints."
		Instructor 02	"Students provided positive feedback on the shorter videos, saying that they liked that it was split up into topics."
		Instructor 02	"Overall it seems to me that students not only preferred the microlearning lessons, but performed noticeably better on coursework due to them."
		Instructor 03	"So he kind of in passing in an email, he mentioned that he did like the splitting of the videos."
		Instructor 03	"I like the idea of the shorter videos. And that's probably in line with what students want."
		Instructor 03	"So it seemed like students were more open to the way that this was or they were open to how this unit was laid out."
		Instructor 03	"Yeah, it seemed to be okay. Which is kind of a good thing because you have two sets of students and they have not said anything like, I don't like this, or the way that you presented the information was didn't really resonate with me."

Theme	Category	Participant Code	Coded Excerpts
	Emotional wellbeing	Instructor 01	“Through my experience with programming classes...you know, it can become very exhausting and tiresome, like really you can get really tired. But it didn’t they didn’t look that. And then when they were done, when I was observing them, they seemed happy as well too.”
		Instructor 02	“By splitting the material into shorter segments to digest, students are less overwhelmed. This seems to allow students to better understand each concept presented, instead of being inundated with so much information.”
Improved Student Performance	Less questions	Instructor 01	“And I think the other piece to it was that I didn't get any questions. No one really asked me anything.”
		Instructor 02	“This past fall semester, I feel like I had less students asking questions.”
		Instructor 02	“Just having less people come in for arrays. Kind of a noticeable drop too, because it’s one of the hardest, like the second hardest topic of the semester.”
		Instructor 03	“It felt like I got less questions about certain things, so I would imagine that they just looked it up and it was easy to identify a video, and what they need to do.”
	Higher scores	Instructor 01	“Most of the scores were quite high for the assessment.”
		Instructor 02	“In addition, the average grades for the quiz and assignment were higher!”
		Instructor 02	“Overall it seems to me that students not only preferred the microlearning lessons, but

Theme	Category	Participant Code	Coded Excerpts
			performed noticeably better on coursework due to them”
		Instructor 03	“Looking at the Average and Over 70% metrics we can see that there was a generally favorable outcome in both metrics with a noticeable dip for Python Quiz 02. For all assessments, the Average percentage was in the low 80s to mid 90s and the Over 70% metric was met. Compared to spring 2023, all assessments were generally higher in both metrics with the exception of Python Quiz 02. However, the Over 70% metric was still met with 76.47% of students achieving at least a 70%.”

Table D4

Themes Reflecting the Students’ Experience with the DO-MDD Framework (Research Question 4)

Theme	Category	Participant Code	Coded Excerpts
Flexible Learning	Learning convenience	Student 01	“If I’m mentally, physically tired...small bites of learning was actually helpful.”
		Student 02	“I personally like it...The pros is that for me, you know, especially for me, a person who has, you know, kids and full time job, it's definitely easier to be able to manage school and my work and my family life. And since it gives more of a freedom, you know, when you can do your school lessons.”
		Student 02	“And then if I had to go and do something for my work, I could always pause it, you know, write down the time just in case it

Theme	Category	Participant Code	Coded Excerpts
			pauses me out when logging out of the LMS. And kind of write down the time when I stopped the video and then I can just go back and resume. So it's really flexible when it comes to that, which made it really easy, really easy for me to get through the course.”
		Student 04	“And it's helped me out quite a bit with time management being able to look through it and having these individual videos. It's just it's a good segmented way of of learning.”
		Student 05	“I think something else that I like is you can go at your own pace. You don't have to like do it all at once. You can take breaks in between as opposed to having like a whole video. And then you have to like, remember the timestamp or remember like, okay wait, I went through this already, so it really helps to like, keep things organized.”
		SQStudent 02	“I also appreciate that it's on youtube, so I can watch it on my tablet when I don't feel like turning on my laptop.”
		SQStudent 18	“Great way to get a lesson done at any time.”
		SQStudent 23	“Love them. Gives more freedom to people who have other responsibilities like jobs and families.”
		SQStudent 28	“Microlearning has its merits, offering bite-sized lessons that are convenient and digestible. It caters to short attention spans, facilitates better retention, and fits well into busy schedules. However, its effectiveness depends on the content and

Theme	Category	Participant Code	Coded Excerpts
			how well it aligns with the overall learning objectives.”
		SQStudent 34	“Microlearning lessons are a convenient way for me to learn. They provide focused content that is easy for me to understand and remember. I can quickly grasp specific concepts or skills without feeling overwhelmed. Microlearning offers flexibility and personalized learning, allowing me to choose when to learn. The modular nature of microlearning also allows me to easily review specific topics. Overall, microlearning is an effective way for me to gain knowledge.”
		SQStudent 38	“I like the freedom it gives to people who have other responsibilities like jobs and kids.”
	On-demand viewing	Student 02	“And then if I had to go and do something for my work, I could always pause it, you know, write down the time just in case it pauses me out when logging out of the LMS. And kind of write down the time when I stopped the video and then I can just go back and resume. So it's really flexible when it comes to that, which made it really easy, really easy for me to get through the course.”
		Student 03	“So with the microlearning videos, It's good because I'm able to pause and, you know, rewind a bit if I need to look over something I don't understand. So that way I'm able to take it, take my time and kind of pace myself, or just kind of like hone what I already know.”

Theme	Category	Participant Code	Coded Excerpts
		Student 04	“I mean, that definitely helps. And you know, instead of attending a lecture where you sometimes won't be able to just go back and figure it out, I can like rewatch things over and over and figure it out that way. So that's good. And yeah, I think, you know, the microlearning videos are great.”
		Student 06	“It was good because if you missed something unlike in real time, you could actually go back to rewind the video a bit and wait. Let me go back a little bit and see what I missed.”
Efficient Learning	Concentration enhanced	Student 01	“I actually enjoyed those classes because they're the classes and so it's somewhat like a broken down to bite size, so it's easier to absorb the information.”
		Student 01	“So like I don't have a whole lot of information all at once going through my head and attempting to understand it. So those definitely those short micro learning definitely helped me in my experience.”
		Student 01	“So you're not being overwhelmed with information, you know, because the first class or the first lesson build up on that on the second one.”
		Student 01	“Yeah, that's really what I like about it. It's not like a blending of information all at once because a lot of this information, especially for ICS, high learning curve for me.”
		Student 04	“So I've really enjoyed that. It's made learning ICS, which is something

Theme	Category	Participant Code	Coded Excerpts
			completely new to me, a lot more manageable.”
		Student 05	“You’re just learning this thing for now. Not everything all at one. So it really helps.”
		Student 05	“It was really helpful because having that short, snippet of learning helped me focus on the objectives.”
		Student 05	“That was a good, it's a good learning approach, especially we have such short attention spans nowadays and it's, it's a good learning method to better grasp concepts and and especially with good visuals.”
		Student 06	“The good aspects to it was that it was shorter. So attention wise, it's a lot easier to capture my attention. I'm a lot more engaged because it's so short.”
		Student 06	“I can sit down and pay attention for 5 minutes. It's not a hard thing. It's not like I'm sitting here for an hour. I'm losing like half my day paying attention to videos.”
		SQStudent 03	“It was very helpful. It did let me to become more focus on the subject.”
		SQStudent 05	“The microlearning is interesting, because I can focus to each parts of the videos, and it structured well with the microlearning.”
		SQStudent 07	“I personally really like the idea of microlearning designed lessons because, tricking my brain with shorter videos made me stay focused and interested in

Theme	Category	Participant Code	Coded Excerpts
			the relating main topics of the python videos. Plus having separate videos for each topic in python was more manageable to remember and know how to write basic programs in python.”
		SQStudent 08	“Good. Lessons were broken down to bit size topics which make learning easier to digest.”
		SQStudent 11	“I think it's an interesting concept and it did help enhance my focus on certain individual items as opposed to the longer lectures. I'm not sure if it's the best or the worst but for me as an individual it seems to have made the lectures feel overall shorter.”
		SQStudent 28	“Microlearning has its merits, offering bite-sized lessons that are convenient and digestible. It caters to short attention spans, facilitates better retention, and fits well into busy schedules. However, its effectiveness depends on the content and how well it aligns with the overall learning objectives.”
		SQStudent 29	“Its easier to digest the information from short videos.”
		SQStudent 31	“One benefit is that they provide bite-sized information, allowing learners to focus on specific topics without feeling overwhelmed. This approach promotes retention and reinforcement, as learners can easily revisit previous lessons.”
		SQStudent 34	“Microlearning lessons are a convenient way for me to learn. They provide focused content that is easy for me to understand and remember. I can quickly

Theme	Category	Participant Code	Coded Excerpts
			grasp specific concepts or skills without feeling overwhelmed. Microlearning offers flexibility and personalized learning, allowing me to choose when to learn. The modular nature of microlearning also allows me to easily review specific topics. Overall, microlearning is an effective way for me to gain knowledge.”
		SQStudent 36	“I like that the videos are shorter. It helps keep my attention compared to 45 min videos.”
		SQStudent 37	“I like it as it help me improve on retaining what I learned, it was easier to digest than conventional methods.”
	Structured clarity	Student 03	“I like the experience in my class this semester because I have three or four videos and just a small amount of subjects covered in each one.”
		Student 03	“Off the top of my head, loops was pretty helpful. Like it was broken down, broken down into three videos and you can get a little bit more detail on each type of loop.”
		Student 03	“The smaller videos were great because you could break it down by subjects and it would be easier to figure out what area or section of the video was. If you had questions about, you could go back to that.”
		Student 05	“But I like how it kind of compounds on top of each other. So you kind of have like the first video and now kind of introduce you to the concept and then it just kind of builds up with each video and, and you

Theme	Category	Participant Code	Coded Excerpts
			kind of explore from there different aspects of whatever we're learning in class.”
		Student 06	“Yeah, I think it was a lot more concise. So instead of having all this background extra in between talking, it was kind of just like, these are the main points. Here’s an example like, I like that it was streamlined and it wasn't like you like when you take courses, sometimes you're in the class and you're like, Wow, this class really could have been an email.”
		Student 06	“I think it kind of mitigated that in the sense that instead of all this random extra, whatever that normally goes on it was short to the point, but still covered everything that it needed to cover.”
		SQStudent 19	“In my opinion, I think microlearning is great because, within a short amount of time, you can gather a lot of information rather than a long video that takes a long time to get the kind of content you need for your programming.”
	Ease of access	Student 03	“It makes it easier because you have it broken down into like certain subjects, into certain videos. So that way you will not have to guess where you were in a longer video.”
		Student 03	“The smaller videos were great because you could break it down by subjects and it would be easier to figure out what area or section of the video was. If you had questions about, you could go back to that.”

Theme	Category	Participant Code	Coded Excerpts
		Student 04	“It's definitely a very helpful concept to have it all broken down individually into short segments. I can kind of look at the title, figure out, you know, I'm kind of understanding this concept, but I want to look at this part.”
		Student 04	“I don't have to skip for a super long lecture, to try to figure out a very distinct part of the lesson plan that I want to figure out. So that's always really helpful.”
		Student 04	“It does the job very well. And I like the segmentation, I like the ease of access and figuring out where I'm at, know what I'm searching for it.”
		SQStudent 12	“It was much easier to go back and reference lectures for studying. The long format lessons were more difficult to go back and review material.”
		SQStudent 25	“I feel like these lessons are much more organized and easier to come back to when you are looking for a certain topic of python. When I needed more information on dictionaries, I easily just went back to the dictionaries video and found the example I was looking for.”
Impact of Video Length	Student Preference	Student 01	“I've noticed the small the short video, shorter video from before was more like ideal for me.”
		Student 01	“I actually like it..I'm not sitting there for good long hours.”
		Student 05	“It's a good way to incorporate into our learning.”

Theme	Category	Participant Code	Coded Excerpts
		Student 06	“When you click on a video that you get from a professor and it says like 40 minutes or an hour or something long. I feel like already then you're losing your audience because your students don't want to watch an hour long video. They're going to just skip through it and try to find important parts. But because it's so short, it's kind of already setting a precedent that everything is important and you don't even need to pay attention that long.”
		SQStudent 02	“It's nice when the lessons are short (under 10-15 minutes).”
	Supports learning	SQStudent 14	“They are helpful ways to learn in bite-size pieces.”
		SQStudent 15	“They are a fantastic tool for helping students learn the content of their course.”
		SQStudent 16	“A fantastic way for students to learn the material from their course.”
		SQStudent 21	“I think microlearning is a much better approach to learning new materials compared to a long hour and a half lecture where you can get stuck on the material while the professor continues the lecture.”
		SQStudent 26	“Although I already knew some python, I felt that these lessons gave me a better understanding of parts I was unsure about and helped me become better at python.”

Theme	Category	Participant Code	Coded Excerpts
Improving the Learning Experience	Desire for immediate feedback	Student 03	“The downside is you wouldn't have immediate feedback from the instructor.”
		Student 06	“The challenge is, I guess is that there's not really real time feedback. So if you do have any questions, you still have to go and message your professor and be like, Hey, I don't understand this, or can you explain this? Which isn't really a problem if it's like a smaller drawback. And the other thing is that depending on how familiar your professor is or the person who's teaching is with recording and teaching online or through videos is, if they're not used to it, they're not going to get their point across.”
		SQStudent 13	“But I do like microlearning, maybe if there was a way to get feedback in real-time or something close to that?”
		SQStudent 32	“I think it is a very functional, streamlined way to educate lots of people in diverse circumstances. Communication with the instructor is key, as not being able to ask questions is an enormous downside on the effectiveness of the learning session.”
	Targeted recommendations	Student 01	“The one suggestion or drawback you felt was that there should have been mini quizzes to also help supplement with the videos with reinforcement.”
		Student 05	“I think just the presentation could have been better if he had used like more PowerPoints or more like more visuals. I think visuals is what needed because when I was watching the videos, I kind of got lost. Also, it helps the videos help,

Theme	Category	Participant Code	Coded Excerpts
			but the same. Yeah, there's the visuals were were lacking.”
		SQStudent 02	“But then, there's a few videos that are really long (30 minutes or so) and that ends up feeling like the content is dragging. I would prefer each video to be similar length of time to the others instead of it being a vast difference of varying times for each one.”

Table D5

Themes Reflecting the Impact of the DO-MDD Framework on Student Learning (Research Question 5)

Theme	Category	Participant Code	Coded Excerpts
Learning Impact of Video Structure	Fewer clarifications needed	Instructor 01	“And I think the other piece to it was that I didn't get any questions. No one really asked me anything.”
		Instructor 02	“This past fall semester, I feel like I had less students asking questions.”
		Instructor 02	“Just having less people come in for arrays. Kind of a noticeable drop too, because it's one of the hardest, like the second hardest topic of the semester.”
		Instructor 03	“It felt like I got less questions about certain things, so I would imagine that they just looked it up and it was easy to identify a video, and what they need to do.”

Theme	Category	Participant Code	Coded Excerpts
Support for learning retention		SQStudent 14	“They are helpful ways to learn in bite-size pieces.”
		SQStudent 15	“They are a fantastic tool for helping students learn the content of their course.”
		SQStudent 16	“A fantastic way for students to learn the material from their course.”
		SQStudent 21	“I think microlearning is a much better approach to learning new materials compared to a long hour and a half lecture where you can get stuck on the material while the professor continues the lecture.”
		SQStudent 26	“Although I already knew some python, I felt that these lessons gave me a better understanding of parts I was unsure about and helped me become better at python.”
		SQStudent 34	“Microlearning lessons are a convenient way for me to learn. They provide focused content that is easy for me to understand and remember. I can quickly grasp specific concepts or skills without feeling overwhelmed. Microlearning offers flexibility and personalized learning, allowing me to choose when to learn. The modular nature of microlearning also allows me to easily review specific topics. Overall, microlearning is an effective way for me to gain knowledge.”
		Instructor 01	“Most of the scores were quite high for the assessment.”
		Instructor 02	“In addition, the average grades for the quiz and assignment were higher!”

Theme	Category	Participant Code	Coded Excerpts
		Instructor 02	“Overall it seems to me that students not only preferred the microlearning lessons, but performed noticeably better on coursework due to them”
		Instructor 03	“In terms of viewer data from YouTube Analytics, the general trend was that students tend to view the videos when the quizzes and assignments are due. Quizzes were due Mondays and assignments were due Tuesdays. Most views were generated around that time frame from Sunday to Tuesday. This is in-line with previous semesters trends.”
		Instructor 03	“Looking at the Average and Over 70% metrics we can see that there was a generally favorable outcome in both metrics with a noticeable dip for Python Quiz 02. For all assessments, the Average percentage was in the low 80s to mid 90s and the Over 70% metric was met. Compared to spring 2023, all assessments were generally higher in both metrics with the exception of Python Quiz 02. However, the Over 70% metric was still met with 76.47% of students achieving at least a 70%.”

APPENDIX E

YouTube Viewing Playlist Data for Instructor 03

Appendix E presents two tables that present YouTube viewing playlist data for Instructor 03's DO-MDD video lessons. Table B1 shows viewing statistics for Spring 2023, while Table B2 covers Fall 2023 statistics. These tables offer insights to student engagement with the DO-MDD video lessons.

Table E1

Spring 2023 YouTube Viewing Playlist Video Data for Instructor 03

Playlist Number/Video Titles	Computer Views	Mobile Phone Views	Tablet Views	Total Views
Playlist 1: Day 1 - Intro to Python <ul style="list-style-type: none">• Introduction to Python• Setting up Python• Hello World• Python Basics• Python if-statements• Python Loops	172	18	2	192
Playlist 2: Day 2 - Lists and Dictionaries <ul style="list-style-type: none">• Lists• Membership Operator• Slicing• Dictionaries	82	11	0	93
Playlist 3: Day 3 - Functions <ul style="list-style-type: none">• Import Statements• Intro to Defining Functions	67	5	11	83

Playlist Number/Video Titles	Computer Views	Mobile Phone Views	Tablet Views	Total Views
<ul style="list-style-type: none"> • Examples of Defining Functions 				
Playlist 4: Day 4 - Program Arguments, Exceptions, Regex <ul style="list-style-type: none"> • Program Arguments • Exceptions • Regular Expressions 	52	7	5	64
Playlist 5: Day 5 - File I/O <ul style="list-style-type: none"> • File I/O • Reading a File Example • Reading a File Example (Using with-as) • Writing a File Example • Writing a File Example (Using with-as) 	21	3	0	24

Table E2

Fall 2023 YouTube Viewing Playlist Video Data for Instructor 03

Playlist Number/Video Titles	Computer Views	Mobile Phone Views	Tablet Views	Total Views
Playlist 1: Day 1 - Intro to Python <ul style="list-style-type: none"> • Introduction to Python • Setting up Python • Hello World • Python Basics • Python if-statements • Python Loops 	160	2	2	164

Playlist Number/Video Titles	Computer Views	Mobile Phone Views	Tablet Views	Total Views
Playlist 2: Day 2 - Lists and Dictionaries <ul style="list-style-type: none"> • Lists • Membership Operator • Slicing • Dictionaries 	63	0	2	65
Playlist 3: Day 3 - Functions <ul style="list-style-type: none"> • Import Statements • Intro to Defining Functions • Examples of Defining Functions 	45	3	3	51
Playlist 4: Day 4 - Program Arguments, Exceptions, Regex <ul style="list-style-type: none"> • Program Arguments • Exceptions • Regular Expressions 	27	0	9	36
Playlist 5: Day 5 - File I/O <ul style="list-style-type: none"> • File I/O • Reading a File Example • Reading a File Example (Using with-as) • Writing a File Example • Writing a File Example (Using with-as) 	35	3	4	42

APPENDIX F

Observed Features of Selected Instructor-Designed Microlearning Video Lessons (Instructors 03 Only)

Appendix F presents a table of observed features from selected microlearning video lessons created by Instructor 03 using the DO-MDD framework. The table includes video titles, durations, and key observed instructional elements such as alignment to a single learning objective, instructional strategies, and engagement techniques. These observations were conducted by the researcher to better understand how the framework was applied in practice and to support interpretation of both instructor-reported and student-reported experiences.

Table F1

Observed Features of Selected Instructor-Designed Microlearning Video Lessons (Instructor 03)

Video Title	Duration	Observed Features
Python 01 – 03: Python Basics	26:56	<ul style="list-style-type: none">• Focused on a single learning objective• Provides examples• Prompts students to pause and reflect during video• Ends with a 10-minute hands-on programming walkthrough
Python 01 – 05: Loops		<ul style="list-style-type: none">• Focused on a single learning objective• Provides examples• Prompts students with a pause and reflect during video

Video Title	Duration	Observed Features
Python 03 – 01: Import Statements	06:54	<ul style="list-style-type: none"> • Ends with 20-minute hands-on programming walkthrough • Focused on a single learning objective • Provides examples
Python 04 – 03: Regular Expressions		<ul style="list-style-type: none"> • Focused on a single learning objective • Provides examples • Ends with 13-minute hands-on programming walkthrough
Python 05 – 01: File I/O	10:55	<ul style="list-style-type: none"> • Focused on a single learning objective • Provides examples • Concluded by explaining that the following videos will cover examples