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### Incorporating Andragogy and Cognitive Theory Of Multimedia Learning Into Self-Paced Training and Development Programs

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INCORPORATING ANDRAGOGY AND COGNITIVE THEORY OF MULTIMEDIA  
LEARNING INTO SELF-PACED TRAINING AND DEVELOPMENT PROGRAMS

A Dissertation Proposal Presented  
To  
The Faculty of the School of Education  
Department of Learning & Instruction

In Partial Fulfillment  
Of the Requirements for the Degree  
Doctor of Education

By  
Shanshan Gao  
San Francisco  
Dec 2022

## THE UNIVERSITY OF SAN FRANCISCO

### **Abstract**

In the modern higher educational system, technology permeated almost all the provisions of educational processes and transformed individual learning transactions. Empirical evidence reveals students' skill gaps in the digitized campus and the real-world work environment driven by technology. Technical training is of high value and in high demand in helping students to develop the skills necessary to carry out schoolwork and be prepared for the real-world work environment.

The purpose of this study was to investigate the effectiveness of the combined method of Andragogy and Cognitive Theory of Multimedia Learning (CTML) in enhancing learning results and optimizing students' learning experience in an asynchronous Excel training program designed on Storyline 360. This study utilized a mixed-method design and was conducted in a private religiously affiliated university on the west coast of the U.S. Quantitative data (i.e., control group  $n=22$ ; Treatment group  $n=22$ ) were collected through quiz and survey to measure learning results and learning motivation, autonomy, and satisfaction respectively. Qualitative data ( $n=4$ ) were collected through semi-structured individual interviews to obtain a deeper insight into the different learning experiences between conventional instruction and the Andragogy and CTML-enhanced instruction.

The first finding of this study was the effectiveness of the interventional training designed with a combined method of Andragogy and CTML in improving students' learning outcomes in the post-test (i.e.,  $t(42) = 2.65$ ,  $p\text{-value} = 0.01 < 0.05$ , Cohen's  $D = 0.80$ ) and maximizing gained scores (i.e.,  $t(42) = 2.23$ ,  $p\text{-value} = 0.03$ , Cohen's  $D = 0.67$ ).

The second finding of the research was that the interventional training designed with a combined method of Andragogy and CTML had a significant effect on improving students' learning motivation ( $t(42) = 2.71$ ,  $p\text{-value} = 0.0096 < 0.05$ , Cohen's  $d = 0.82$ ), but no effect on improving learning autonomy ( $t(42) = -0.17$ ,  $p\text{-value} = 0.87 > 0.05$ , Cohen's  $d = -0.05$ ) and learning satisfaction ( $t(42) = 1.43$ ,  $p\text{-value} = 0.16 > 0.05$ , Cohen's  $d = 0.42$ ).

The third finding of this research revealed: (1) learners found both the conventional and the Andragogy and CTML-enhanced training beneficial as it met their current or future needs; (2) learners in both groups were engaged in the micro-learning experience multimedia-based (i.e., simulations and mind maps); (3) Project-based assessment and brief course navigation instructions are preferred in the self-paced training.

This study formulated an evidence-based framework to design effective online technical capability-building solutions that are centered on the needs of learners. Educational leaders should enable instructional technologies and define governance and processes to support the integration of the combined andragogy and CTML method. Additional research implementing the andragogy and CTML approach with learners in different educational settings and subject matters would further expand the findings and drive teaching innovations.

## Signature Page

This dissertation, written under the direction of the candidate's dissertation committee and approved by the members of the committee, has been presented to and accepted by the Faculty of the School of Education in partial fulfillment of the requirements for the degree of Doctor of Education. The content and research methodologies presented in this work represent the work of the candidate alone.

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## **Dedication**

To the moment I determined to transform myself; To those who nurtured and protected my dream; And to those who resolved to define who you are and what you can do in the world!

## **Acknowledgment**

I am deeply indebted to so many people in the world, my families, professors, friends, classmates, co-workers, and my cat Aphrodite. First, I would like to express my deepest gratitude to my dearest uncle, who fueled my passion, nurtured my dream, and supported me unconditionally. Second, I would like to express my heartfelt gratitude to my dissertation committee chair, Dr. Sedique Popal, who believed in my potential and ability to succeed in my dissertation. I will always remember his remarkable working spirit of reading my dissertation during his Covid and holiday time. Third, I would like to sincerely thank my committee member Dr. Mathew Mitchell and Dr. Kevin Oh, who read my dissertation on holidays and provided me with so much insightful feedback! I would like to extend my thanks to Dr. Patricia Busk, who helped me shape the structure of my research design and set my work up to succeed. I am lucky to have such a remarkable group of career idols and life mentors in the doctorate journey!

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# CHAPTER I

## INTRODUCTION

*“We are on the cusp of a completely “new era”, and changes must be made in education to ensure that all students leave school prepared to face the challenges of a redefined world.”*

*(Thornburg, 2000)*

Originating from applied psychology in the early 1900s, the scope of Training & Development (T&D) has expanded into numerous fields (Bell, 2017). In the Human Resource Management field, T&D plays a significant role in closing employees’ performance gaps, strengthening their skills, and enhancing their employment competency. Training provides individuals with the skill and knowledge to perform routine tasks, while development prepares them for future career responsibilities through continual learning (Vinesh, 2014). Training is usually skills-based and used to improve an employee’s job-related knowledge, including technological skills, team collaboration, cross-cultural communication, conflict management, project management strategies, and customer service skill. In contrast, development usually is individual-based and a long-term investment that leads to career growth (Furnham, 2005).

Khan and Abdullah (2019) defined T&D as organizational activities to facilitate individual performance and the achievement of groups. Ershad (2017) pointed out that T&D can have a significant role in addressing employees’ weaknesses, and increasing their productivity, accuracy, and consistency in duty performance. T&D also plays a substantial role in organizational development as it optimizes the utilization of talent assets, enhances the corporate image, and improves the sustainability and competitiveness of the organization thus preventing obsolescence (Ershad, 2017). With the continuous change in the work environment, the goals of T&D have expanded beyond preparing employees with the necessary skill to improve productivity,

efficiency, and accuracy on work-related tasks. Today, T&D is viewed as a valuable tool to improve the effectiveness of a team and to gain a competitive advantage for an organization (Noe et al., 2014).

In higher education, T&D plays a significant role in developing educators' technological literacy, which drives innovative pedagogy in various fields (Khan and Abdullah, 2019). The advent of computer technology and the decrease in the cost of technology have enabled a burgeoning adoption of instructional technology in educational institutions. With the ever-growing need for a modern education system, the education industry has become more tech-savvy, dynamic, and updated (Khan and Abdullah, 2019). Avello and Duarte (2016) suggested that this could open up new possibilities and areas of interest in innovative teaching. Technology plays an important role in facilitating students' self-paced studying, enhancing active and interactive learning, changing the learning culture, and digitizing assessment (Jääskelä et. al., 2017). According to the National Education Technology Plan (NETP) (2017), technological advancements help in reinventing our approaches to collaboration and learning, advancing the relationships between students and educators, shrinking the equity and accessibility gaps, and adapting learning experiences that meet the needs of all learners. The consideration of *whether technology should be used in education* has been switched to *how it can facilitate effective learning*.

### **Statement of the Problem**

In modern higher educational system, technology permeated almost all the provisions of educational processes and transformed individual learning transactions. Technical training has burgeoned into a viable capability building protocol that support the continuing learning needs and professional development of the faculty, staff, and students. While research regarding the training



provisions such as formal in-service, mentoring, workshops, peer observations, and professional learning community have been ongoing for several decades, the investigation on the self-paced eLearning is still in the early stage. Multimedia instruction, grounded in CTML, is one of the dominant representational formats for software training in T&D. There have been studies focused on the effectiveness of demonstrated video in technical training. Chen & Yang (2020) finds that multimedia instruction such as narrated demonstration and animated demonstration tend to increase transfer performance; Van der Meij (2019) asserts the same claim. Van der Meij et al (2018) further suggests the effectiveness of video tutorials in leveraging learning motivation and task performance.

However, the effectiveness of other multimedia formats, such as mind maps and situated practice that have been demonstrated to be effective in other subject matter, have not been investigated in software training in the T&D of higher education. Additionally, these studies use a pedagogical paradigm and fail to take into account adults' unique learning characteristics. An effective integration of self-paced technical training requires multiple representative formats and keen consideration of adult students' unique learning characteristics. Thus, this study seeks to investigate the effectiveness of a combined method of CTML and andragogy in software training of T&D in higher education setting.

### **Background and Need**

With the ubiquitous of technology, teaching and learning has been transformed into a technical process, featuring a modern educational system driven by technology. The educational leadership has concerned that instructors and students lack the digital literacy necessary to adapt to the pace of technological advancement (Bichsel, 2013). Responding to the demands of the digital education system, numerous universities establish T&D programs to prepare instructors to

deploy educational technology effectively (e.g., Muianga et al., 2019; Neves and Henriques, 2020; Kasani et al., 2020; Dhillon and Murray, 2021). These programs play a crucial role in closing the digital literacy gap of the instructors and preparing them to be able to support student needs when using technology as a tool to transform learning experiences (Muianga et al., 2019; Dhillon and Murray, 2021). Khan and Abdullah (2019) carried out a study to investigate the impact of T&D on teachers' productivity and performance. They concluded that there exists a strong and positive relationship between T&D and the productivity of the teachers. Effective T&D programs for faculty play a pivotal role in innovating the instructions and thus improving students' learning experience and academic performance in the modern education system.

Even though instructors have the obligation to support students' utilization of technology to perform learning-related activities, students are still expected to be able to use technology in active and creative ways independently. In 1996, International Technology Education Association (ITEA) published an initial statement and policy document called "Technology for All Americans: A Rationale and Structure for the Study of Technology". The principal rationale for this policy is that every citizen in the United States should be "technologically literate and, thereby, able to use, manage, and understand technology" (ITEA. 2000). In recent years, technology has already transformed teaching and learning in higher education.

Several states and school systems have already established T&D programs to enhance instructors' technological literacy. However, there still exists a technological gap among numerous students that impede them to adopt the digitized tools in the technology-driven learning system. Empirical evidence reveals students' challenges and discomfort in using technology to fulfill learning activities, such as participating in the online discussion, learning at a distance, and engaging in technology-based assignments (e.g., Ilonga et al., 2020; Stenhoff et al., 2020; Lynn et

al., 2020). Therefore, students are in urgent need of a T&D program that is designated to close their skill gaps and improve their learning performance in school (Ilonga et al., 2020; Sim et al., 2020; Gelles et al., 2020).

Moreover, beyond the campus, the work environment is more and more driven by technology. Over the past decade, the global workforce has been continually evolving due to several factors. As Nick (2018) stated, “an increasingly competitive business landscape, rising complexity, and the digital revolution are reshaping the mix of employees” (p. 18). Nick (2018) believed that “persistent uncertainty, a multigenerational workforce, and a shorter shelf life for knowledge have placed a premium on reskilling and upskilling” (p. 18). The shift to a digital, skill-based workforce means that students in higher education need more than academic knowledge of a certain field.

Although students in the 21st century are dependent on current technology, there is still a technological gap between what is taught in school and what is needed for success in today’s workplace (Percival, 2018). The educational system should prepare them to be successful in an ever-changing technical world. Cobo and Moravec (2011) pointed out that “higher education must focus on the preparation of students to learn, to become autonomous in their process of accessing and selecting relevant information, and to adapt to changing needs throughout their professional lives”. Required technological skills are more important than ever for higher education graduates to be competitive in the job market.

Given students’ skill gaps in the digitized campus and the employment market, T&D is of high value and in high demand in helping them to develop the skills necessary to carry out schoolwork and be prepared for the real-world work environment drive by technology. While many universities provide centralized technology support for faculty and students, there is still a

lack of efficient T&D programs that fit students' schedules, promote learning results, and meanwhile, support their professional goals.

### **Purpose Statement**

The purpose of this study was to investigate the effectiveness of the combined method of Andragogy and cognitive load of multimedia learning (CTML) in: (1) enhancing learning results in T&D programs in higher education; and (2) optimizing students' learning experience regarding learning motivation, autonomy, and satisfaction. This research discussed the incorporation of Andragogy principles into the online learning design to leverage university students' learning experiences such as learning motivation, autonomy, and satisfaction. Then the research deliberated CTML principles that are designated to help learners to master the targeted technological skills effectively. The study further elaborated on the integration of a combined method of Andragogy and CTML to improve the learning experience and facilitate learning results in the self-paced T&D program in higher educational settings.

The researcher collaborated with the ITT staff to design a self-paced online learning experience grounded in the Andragogy and CTML. The learning results were measured by multiple-choice quizzes for participants who took the conventional training (i.e., control group) and Andragogy and CTML-enhanced training (i.e., treatment group). Learning experiences regarding learning motivation, autonomy, and satisfaction were investigated through a survey. Semi-structured Zoom interview was conducted to dive in learners' perspective regarding the conventional training and CTML-enhanced training, respectively.

### **Theoretical Framework**

This dissertation was buttressed by two of the scientific learning theories that exert significant value in education: (a) Knowles's (1989, 2015, 2020) Andragogy and (b) Mayer's (2003, 2020) cognitive theory of multimedia learning.

## **Andragogy**

The first theory that comprised the framework for this study is Andragogy, also referred to as *adult learning theory*. *Andragogy*, the art and science of helping adults learn (Knowles, 1968, 1980), has been alternately described as “a set of guidelines” (Merriam, 1993), “a philosophy” (Pratt, 1993), “a set of assumptions” (Brookfield, 1986), and “a theory” (Knowles, 1989; Knowles et al., 2015). It is not solely limited to one particular field of study or even the classroom context. It has been used in almost any context where an adult may be conceived as a learner, including business, education, religion, athletics, and law (Shostak et al., 2022).

Alexander Kapp, a German high school teacher, first used the word "Andragogy" in 1833 to describe lifelong learning and the importance of self-reflection and life experience in learning. In the United States, Lindeman was the first to write about *Andragogy* and its application to teaching adults (Shostak et al., 2022). Malcolm Shepherd Knowles, the executive director of the Adult Education Association of the United States of America, was the first to bring *Andragogy* to the forefront in the 1960s in the United States (Shostak et al., 2022) in an attempt to document the differences between the learning approaches of adults and children (Knowles et al., 2015). Observing an unusually high rate of school dropout for adult learners motivated him to study the roots and causes of learners' dissatisfaction in adult education programs. He noticed that learners' self-concept was a dependent recipient of information and teachers were continuing to use pedagogical approaches (Knowles, 1984). Given the tremendous contributions of his work,

Knowles is often considered the father of adult education (e.g., Fornaciari and Lund Dean, 2014; Giannoukoset al., 2015; Watts, 2015).

Knowles considered teachers as a facilitator of learning, rather than an oracle of learning who pass down knowledge passively. Based on Pashko (2013) and Shostak et al. (2022), a comparison of the main provisions of Andragogy and pedagogy can be summarized in Table 1.

**Table 1**

*Comparison of the leading provisions of pedagogy and Andragogy based on Pashko (2013) and Shostak et al. (2022).*

	Andragogy	Pedagogy
	Teaching adult	Teaching children
Independence	An adult is autonomous, an independent decision-maker	The child is addicted, directed by an adult
	Mutual exchange of training transactions.	Teacher dominates – dependent learning.
	Mutual assistance relationships	Mentoring relationships.
Experience and communication	Ability to take/ connect with life	Limited life experience
	The multifaceted focus of communication is between everyone	One-way communication – from teacher to student
	Everyone's experience is valued as a learning resource.	Teacher experience is valued as the main course
Willingness to learn	An adult knows what he wants to learn and why.	The training course is defined in advance
	Participants are grouped into interest groups	Learners are grouped by marks and grades
Time perspective /	The need to apply knowledge	The child learns for the

Orientation in learning	in life/work as soon as possible	future, “stores” knowledge
	Emphasis on the problem	Emphasis on the subject
	Work on today's problems today	Work on today's problems today

Based on the characteristics of adult learners, Knowles et al., (2020) posited a set of assumptions about adult learners, which constitute the andragogical model. The assumptions of Andragogy include: (a) *The need to know*. Adults need to know the objective of learning a subject matter prior to undertaking its learning; (b) *The learners’ self-concept*. “Adults have a self-concept of being responsible for their own decisions and for their own lives, which helps them to make the transition from dependent to self-directing learners”; (c) *The role of the learners’ experiences*. Adults participate in learning activities with a great reservoir of life experience which is a valuable resource for the learner and their peer cohort. New information is processed through the lens of life experiences; (d) *Readiness to learn*. As adults mature, they tend to learn knowledge associated with their particular social roles and developmental tasks. The *readiness to learn* varies as they move from one life stage to the next; (e) *Orientation to learning*. “In contrast to children’s and youths’ subject-centered orientation to learning (at least in school), adults are life-centered (or task-centered or problem-centered) in their orientation to learning. Adults are motivated to learn what they perceive will help them perform tasks or deal with problems they confront in their life situations”; and (f) *Motivation to learn*. It is the intrinsic motivation that drives adults to learn, despite the responsiveness to external incentives ((Knowles et al., 2020, pp. 44-46)).

The number of andragogical principles has grown from four to six over the years as Knowles refined his thinking. Originally, *Andragogy* presented four assumptions (Knowles, 1975, 1978, 1980b). The motivation to learn, the last assumption, was added in 1984 (Knowles, 1984),

and the first assumption, the need to know, in more recent years (Knowles, 1987, 1989, 1990). These assumptions are not intended to be viewed as a universal recipe applicable in all situations, but rather as a set of flexible assumptions to be adopted, adapted, or altered depending on the situation. Knowles (1984) stated this point in the conclusion to his casebook examining 36 applications of Andragogy. He noted that:

1. “The andragogical model is a system of elements that can be adopted or adapted in whole or in part. It is not an ideology that must be applied totally and without modification. In fact, an essential feature of Andragogy is flexibility” (p. 418).
2. “The appropriate starting point and strategies for applying the andragogical model depend on the situation” (p. 418).

Knowles et al. (2015) see Andragogy “as a set of core adult learning principles that apply to all adult learning situations” (p.17). However, Pratt (1988) pointed out that most learning experiences are highly situational, and that a learner might show very different behaviors in different learning situations. This resulted in “the need for a contingency framework that avoids a one-size-fits-all approach and offers more clear guidance to adult educators” (Knowles et al., 2015, p. 76). Knowles et al., (2015) indicate that the need here is to clarify Andragogy by a more explicit consideration of key factors that could affect the application of andragogical principles. Thus, the proposed the *Andragogy in a Practice Model (APM)* that attunes users to key factors that affect its use in practice.

APM, a framework depicted in Figure 1, is an enhanced conceptual framework for a more systematic application of Andragogy across multiple domains of adult learning practice. The three dimensions of APM, shown as rings in the figure, are

- (1) goals and purposes for learning,



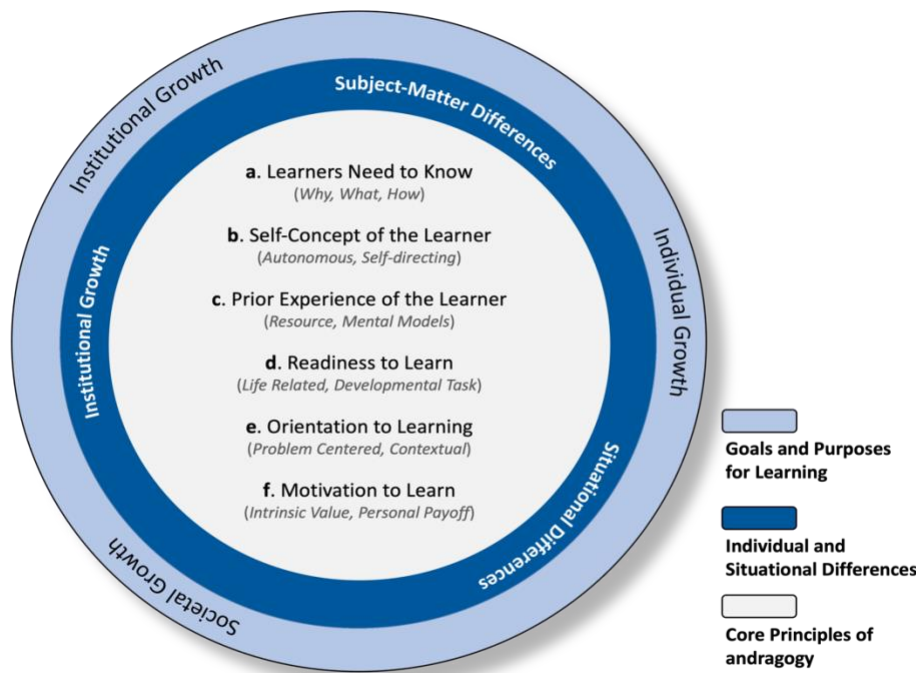
(2) individual and situation differences, and

(3) Andragogy: core adult learning principles.

This framework conceptually integrates the added learning influences with the core adult learning principles. The three rings of the model, as depicted in Figure 1, interact and offer a three-dimensional process for understanding adult learning. Goals and purposes for learning, the outer ring of the model, are portrayed as developmental outcomes. In this model, “goals for adult learning events may fit into three general categories: individual, institutional, or societal growth” (Knowles et al., 2015, p. 77). Individual and situational differences, the middle ring of the Andragogy in the practice model, are portrayed as variables. These variables are: subject-matter differences, situational differences, and individual learner differences. The core adult learning principles, the inner ring of the model, provide a sound foundation for planning adult learning experiences.

### **Figure 1**

*Andragogy in Practice Model (APM) after Knowles et al. (1998)*



Adult learning principles “work best in practice when adapted to fit the uniqueness of the learners and the learning situation” (Knowles et al., 2015, p. 17). Their strength is that these core principles apply to all adult learning situations, as long as they are considered in concert with other factors that are present in the situation. The APM informs educational professionals to take contextual analysis as a step in developing T&D programs.

The researcher of this study adapts the *andragogical in-practice model* in this dissertation to provide theoretical support for the effectiveness of adult learning principles on students’ learning outcomes in T&D. Thus, the core adult learning principles shape the design and development of the asynchronous e-Learning experience in this study. Knowles et al. (2020) indicated that to utilize the APM, one needs to perform an *andragogical learner analysis*. Given the wide range of backgrounds, educations, experiences, interests, motivations, and abilities that

characterize the adult group in this study, the researcher believes a self-paced e-Learning T&D program works the best in practice as it allows individuals to tailor their own learning plans.

T&D plays an important role in helping learners achieve their potential by addressing their weaknesses and increasing productivity, accuracy, and consistency in duty performance. Adapting the andragogical model in the T&D program facilitates new educational models designed to better meet workforce needs critical to the institution and the nation. This model informs the T&D program to adapt to changes in workforce demand and adjust course delivery approaches to deal effectively with learner variability and enable the individual's personal growth. The author of this study strategically incorporated Andragogy to build sustainable and flexible professional learning for learners in higher education.

### **The cognitive theory of multimedia learning**

The second theory of prominence factored into this study is the CTML, which has been popularized by Richard E. Mayer and others (e.g., Mayer & Moreno, 1998; Mayer, 2001; Mayer, 2003); Mayer & Fiorella, 2014; Mayer, 2020). This theory provides evidence-based insight on transforming knowledge information into a multimedia-based learning representation, which enables learners to process information effectively with limited cognitive capacity. Mayer indicates that “Baddeley's model of working memory, Paivio's dual coding theory, and Sweller's theory of cognitive load are integral theories that support the overall theory of multimedia learning” (2020, pp. 85-99). Mayer explained, CTML “is based on three basic assumptions about how the human mind works – namely, that the human mind is a dual-channel, limited-capacity, active-processing system” (Mayer, 2020, p. 99):

- a) *Dual-Channels Assumption*: Human process visual/spatial and auditory/verbal information from separate channels. For instance, when visual materials such as

illustrations, animations, video, or onscreen text are presented to the eyes, humans begin by processing that information in the visual channel. On the other hand, when auditory materials such as narration or non-verbal sounds are presented to the ears, their information is processed in our auditory channel (Mayer, 2020). The concept of separate information processing channels has a long history in cognitive psychology and is most closely associated with Paivio's dual-coding theory (Clark and Paivio, 1991; Paivio, 1986, 2006) and Baddeley's model of working memory (Baddeley, 1999; Baddeley, et al., 2015). Mayer believes "the verbal and visual channels in our working memory can be used for processing information simultaneously thus enhancing the process of learning" (Mayer, 2020, p. 90).

b) *Limited-Capacity Assumption*: The amount of information that can be processed in each of our processing channel at a time is limited. As an example, when an animation is presented to a learner, he/she could hold only a few images in his/her visual channel of working memory at any moment, reflecting only portions of the presented material rather than its exact copy. Similarly, when a narration is presented, the learner could only perceive a few words in the verbal channel of working memory at any one time (Mayer 2020). The conception of limited capacity in consciousness also has a long history in psychology. Some modern examples are Baddeley's (1999; Baddeley et al., 2015) theory of working memory and Sweller's (1999; Kalyuga, 2011) cognitive load theory.

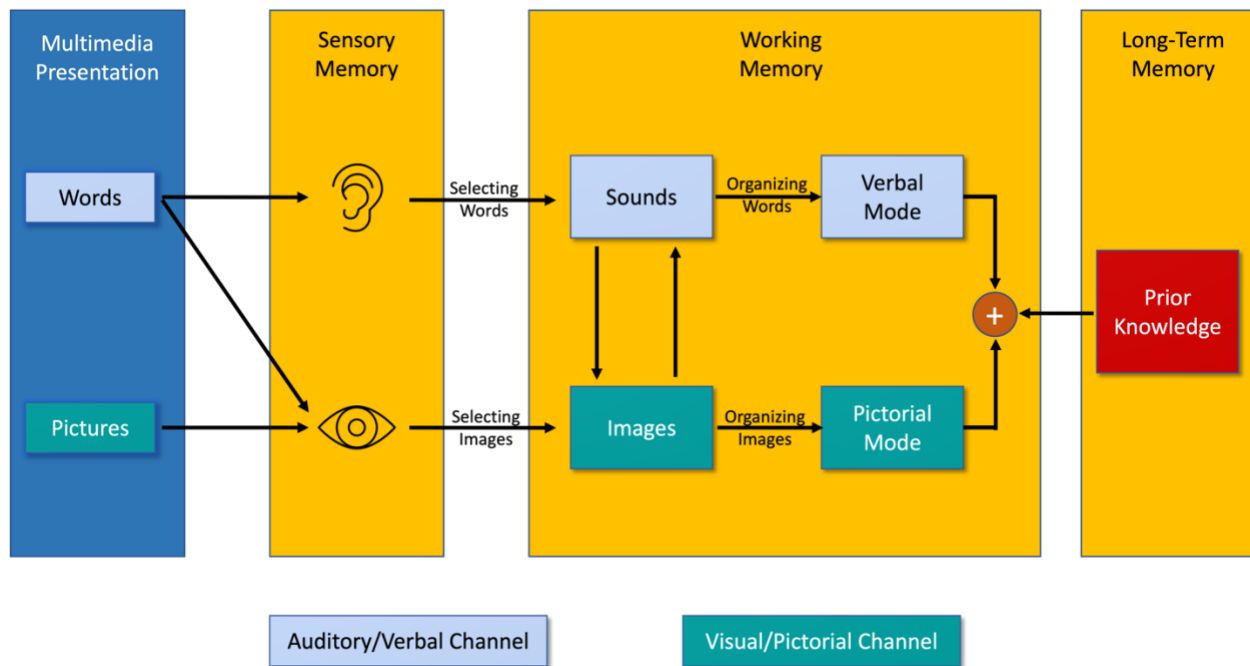
c) *Active Processing*: Humans do not learn by just passively absorbing information. Instead, humans actively engage in cognitive processing of information to construct a coherent mental representation of their learning experiences. This active cognitive processing includes highlighting relevant information received, organizing them into a coherent cognitive structure, and integrating them with prior knowledge (Mayer, 2020).

Mayer regards humans as “active processors who seek to make sense of multimedia presentations” (Mayer, 2020, p. 95).

Based on the three assumptions stated above, Figure 2 below represents multimedia learning in the human information processing system. In accord with the dual-channel assumption, “the sensory memory and working memory is divided into two channels – the one across the top deals with auditory sounds and eventually with verbal representations, whereas the one across the bottom deals with visual images and eventually with pictorial representations” (Mayer, 2020, p. 100). According to the limited-capacity assumption, “working memory is limited in the amount of knowledge it can process at one time so that only a few images can be held in the visual channel of working memory and only a few sounds can be held in the auditory channel of working memory” (Mayer, 2020, p. 100). As the active-processing assumption indicates, learners actively select knowledge to be processed in working memory, organize the material in working memory into coherent structures and integrate the newly acquired knowledge with knowledge stored in long-term memory (Mayer, 2020, p. 101), which can in turn facilitate new information processing that comes into the working memory.

**Figure 2**

*Mayer’s Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2020)*



The left side of Figure 2 represents the raw information/materials (i.e. visual images of pictures and sound images of words) that comes into working memory. The mental conversion of a sound into a visual image and vice versa are represented by the arrow from sound to images and the arrow from images to sound respectively. The right side of Figure 2 represents the long-term knowledge (i.e. pictorial and verbal mental models and links between them) that is constructed in working memory. The long-term memory can store large amounts of knowledge over a long period of time, unlike working memories (Mayer 2020). The long-term memory can store large amounts of knowledge over a long period of time, unlike working memories (Mayer 2020). The red box on the right side labeled *Prior Knowledge* indicates that learner's relevant prior knowledge in the long-term memory can in turn facilitate process new information that came into the working memory. When learning new knowledge, relevant knowledge storehouse helps working memory to absorb new information and organize it into established mental representation in the long-term memory.

Learners store the information in three types of memories: (a) sensory memory where we receive stimuli and store it for a very short time; (b) working memory in which we actively process information and create mental models or schema; and (c) long-term memory where all things that

have been learned are stored (Mayer, 2020). The central work of multimedia learning takes place in working memory. Table 2 summarizes the characteristics of the three memories drawn from the CTML.

**Table 2**

*Three Types of Memory Stores based on Mayer (2020)*

Memory store	Description	Capacity	Duration	Format
Sensory memory	Briefly holds sensory copies of incoming words and pictures	Unlimited	Very brief	Iconic and auditory sensory representations
Working memory	Allows for holding and manipulating incoming sounds and images	Limited	Short	Pictorial and verbal representations
Long-term memory	Permanently stores organized knowledge	Unlimited	Permanent	Knowledge

CTML has spawned the research of multimedia design in e-Learning, which contains a series of guiding principles for evidence-based practice. Clark and Mayer (2016) eloquently summarized evidence-based guidelines for online learning. These design principles are stipulated in the following Table 3.

**Table 3**

*Prominent Multimedia Principles with Explanation*

Multimedia principle	Explanation
Multimedia principle	“Learners learn better from words and pictures than from words alone” (Mayer, 2020, p. 34).

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Modality principle	“People learn more deeply from pictures and spoken words than from pictures and printed words” (Mayer, 2020, p. 634).
Spatial contiguity principle	“People learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen.” (Mayer, 2020, p. 477).
Redundancy principle	“People do not learn better when printed text is added to graphics and narration” (Mayer, 2020, p. 433).
Coherence principle	“People learn better when extraneous material is excluded rather than included” (Mayer, 2020, p. 332)
Personalization principle	“People learn better when e-learning environments use a conversational style of writing or speaking (including using first- and second-person language), polite wording for feedback and advice, and a friendly human voice” (Clark and Mayer, 2016, p. 179).
Embodiment principle	“People learn more deeply from multimedia presentations when an onscreen instructor displays high embodiment rather than low embodiment” (Mayer, 2020, p. 772).
Segmenting principle	“People learn better when a multimedia message is presented in user-paced segments rather than as a continuous unit” (Mayer, 2020, p. 562).
Pre-training principle	“People learn more deeply from a multimedia message when they know the names and characteristics of the main concepts” (Mayer, 2020, p. 601).

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The researcher of this study drew on Mayer’s (2005, 2014, 2020) CTML in this dissertation so as to provide a theoretical foundation for the effectiveness of a cognitive method on students’ learning outcomes and experiences. Mayer (2020, p. 90) indicates that “using two separate but



interrelated verbal and visual systems in vocabulary instruction allows the learners to benefit even more when they learn the target words through such multimedia presentation by triggering both the auditory/verbal channel and the visual/pictorial channel.” Eshghavi (2020) indicates that “employing this cognitive technique can help learners to establish a direct mental connection between visual and auditory models and facilitate the knowledge construction in the working memory.” The researcher believes that higher education learners can comprehend and transfer technical skills when the instruction provides two or more modalities, such as the visual modality and the auditory modality, at the same time rather than only through one of the modalities alone.

The researcher of this study drew on the multimedia principles of CTML to shape the design, development, and evolution of self-paced online learning. Incorporating these principles enables the learners to eliminate this extraneous processing and thus make the best use of the limited processing capacity to process the information relevant to the instructional goals. For instance, in the light of the modality principle, the e-Learning course in this study presented words in spoken form rather than printed form with the promise to help learners to “off-load processing of words from the visual channel to the auditory channel, thereby freeing more capacity for processing graphics in the visual channel” (Clark and Mayer, 2016, p. 114). This study applies the multimedia principles of CTML to help learners to facilitate the cognitive processing and effective retrieval of the information stored in long-term memory, and thus optimizes the promise of multimedia learning in eLearning environments.

### **Research Questions**

The research questions that were investigated in this dissertation are as follows:

1. To what extent was there a difference in the learning outcomes between the participants who took the conventional training and the participants who took Andragogy and CTML-enhanced training as measured by the pre-and post-test scores?
  - a. To what extent was there a difference in the pre-test score between the comparison and the treatment group?
  - b. To what extent was there a difference in the post-test score between the comparison and the treatment group?
  - c. To what extent was there a difference in the gained score between the comparison and the treatment group?
2. To what extent was there a difference in the learning experience between the participants who took the conventional training and the participants who took Andragogy and CTML-enhanced training?
  - d. To what extent was there a difference in learning motivation as measured by the Likert scale of a survey?
  - e. To what extent was there a difference in learning autonomy as measured by the Likert scale of a survey?
  - f. To what extent was there a difference in learning satisfaction as measured by the Likert scale of a survey?
3. How was the learning experience different between the participants who took the conventional training and the participants who took Andragogy and CTML-enhanced training?

### **Significance of the Study**

The advent of computer technology and the decrease in the cost of technology have burgeoned digital adoption in both the educational sector and the corporates. Technical training programs in higher education enable students to develop digital literacy that helps them to adapt to the modern educational system and the 21st-century workforce. This research is significant because results arising from the study exerted both academic and practical implications for stakeholders such as researchers, teachers, students, instructional designers, educational administrators, educational policymakers, educational institutions, and corporations.

This study found that the combined method of Andragogy and CTML can significantly improve student's learning outcome and learning motivation in the T & D program.

In terms of the academic implications, this study filled a gap in the literature investigating the effect of Andragogy and CTML-enhanced T&D training model on students' learning outcomes and leaning experiences. While research regarding the training provisions such as formal in-service, mentoring, workshops, peer observations, and professional learning community has been ongoing for several decades, the investigation on the self-paced eLearning is still in the early stage. Multimedia instruction, grounded in CTML, is one of the dominant representational formats for software training in T&D. There have been studies focused on the effectiveness of demonstrated video in technical training (i.e., Chen & Yang, 2020; Van der Meij, 2019). However, the effectiveness of other multimedia formats, such as mind maps and simulations that have been demonstrated to be effective in other subject matter, have not been investigated in software training in the T&D of higher education. Additionally, previous studies use a pedagogical paradigm and fail to consider adults' unique learning characteristics. Thus, this study filled the vacuum niche of incorporating two evidenced-based learning theories into self-paced technological training

programs. Further, given that few studies have streamlined the process of designing, developing, and evaluating a technology training program, this research could serve as a robust reference guide for future scholars to investigate other instructional methodologies for effective T&D development. Last, this study formulated a research design for future scholars to replicate to investigate viable eLearning solutions for a robust T&D program.

This study also exerted significant practical implications for institutional stakeholders. Specifically, this study will: (a) help educational practitioners to effectively utilize the andragogical principles to address the unique contextual obstacles of young adult learners in online learning settings; (2) inspire educational practitioners with new insight of integrating instructional initiatives grounded in multimedia; (3) inform the educators of a theory-grounded framework to design effective online technical capability building solutions that are centered in the needs of learners; (4) provides learners a one-stop learning experience for them to learn and to play the target skill in a flexible, safe, and effective learning setting; (5) provides institutions with effective training strategies that are transferable, economical, re-usable, and scalable.

### **Definition of Terms**

**Andragogy:** Andragogy is an “andragogical model focuses on the education of adults and is based on the following precepts: adults need to know why they need to learn something; adults maintain the concept of responsibility for their own decisions, their own lives; adults enter the educational activity with a greater volume and more varied experiences than do children; adults have a readiness to learn those things that they need to know in order to cope effectively with real-life situations; adults are life-centered in their orientation to learning; and adults are more responsive to internal motivators than external motivators” (Knowles et al., 2015, p. 52).

**Asynchronous e-Learning:** Asynchronous e-Learning is “similar to synchronous e-Learning which is a learner-centered process which uses online learning resources to facilitate information sharing regardless of the constraints of time and place among a network of people” (Shahabadi and Uplane, 2015).

**Cognitive theory of multimedia learning:** As set forth by Mayer, “the cognitive theory of multimedia learning is based on three main assumptions: (a) there are two separate channels (auditory and visual) for processing information; (b) there is limited channel capacity; and (c) learning is an active process of filtering, selecting, organizing, and integrating information” (Mayer, 2014, p. 47). The basic premise of the cognitive theory of multimedia learning is that “people learn more deeply from words and pictures than from words alone” (Mayer, 2014, p. 47).

**Development:** Development is a continuous interaction of work and leisure across the life span in a series of transitional situations (Reno and Preston, 2014).

**Dual Coding Theory:** A learning theory that is “based on the assumption that both visual and verbal information is processed along different channels in the brain” (Paivio, 1986).

**e-Learning:** eLearning is “a format of instruction delivered on a digital device (such as a desktop computer, laptop computer, tablet, or smartphone) that is intended to support learning” (Clark and Mayer, 2016, p. 8).

**Multimedia learning:** Mayer & Moreno (2003) define multimedia learning as “learning from words and pictures” (p. 43).

**Multimedia instruction:** Mayer & Moreno (2003) define multimedia instruction as “presenting words and pictures that are intended to foster learning. The words can be printed (e.g., on-screen) or spoken (e.g., narration). The pictures can be static...or dynamic (e.g., animation, video, or interactive illustration)” (p. 43).

**Organizational Learning:** Organizational learning is “the process through which an organization constructs knowledge or reconstructs existing knowledge” (Huysman, 2000, p. 135). Therefore, according to Knowles (2013), organizational learning is “the structures, processes, and networks that facilitate the creation and dissemination of knowledge within and between organizations” (Knowles, 2013, p. 2).

**Synchronous e-Learning:** Synchronous e-Learning is conducted in real-time with a live instructor. The synchronous e-Learning is “similar to a regular classroom, except learners can take courses anywhere in the world as long as they have access to a computer, internet connection, and access to audio or video conferencing” (Arshavskiy, 2017, p. 9).

**Training:** Training is “the systematic acquisition of skills, rules, concepts, or attitudes that result in improved performance in another environment” (Goldstein and Ford, 2002, p. 1).

**Training and Development:** Training and Development refers to educational activities within a company to enhance the knowledge and skills of employees while providing information and instruction on how to better perform specific tasks (Vinesh, 2014).

### **Summary**

Technology is ubiquitous and we are in the midst of a digital revolution. With the ever-growing needs of the modern education system, the education industry has to become more tech-savvy, dynamic, and updated (Khan and Abdullah, 2019). To fully utilize the advantages of this digital revolution in our educational institutions, students need to be equipped with the right skills, knowledge, and abilities to perform their assigned tasks in school. Moreover, the shift to a digital, knowledge-based economy means that students in higher education with a mastery of technical skills are more competitive in the employment market.

However, empirical studies revealed students' challenges and discomfort in using technology to fulfill learning activities, such as participating in the online discussion, learning at a distance, and engaging in technology-based assignments (i.e., Ilonga et al., 2020; Stenhoff et al., 2020; Lynn et al., 2020). Moreover, beyond the campus, the work environment is more and more driven by technology. Although students in the 21st century are dependent on technology, there is still a technological gap between what is taught in school and what is needed for success in today's workplace (Percival, 2018).

Given students' skill gaps in the digitized campus and the employment market, technological training is of high value and in high demand in helping them to develop the skills necessary to carry out schoolwork and be prepared for the real-world work environment driven by technology. Previous studies have investigated the effects of the individual method of Andragogical model (i.e., Rathner & Schier, 2020) and CTML (i.e., Alpizar et al., 2020; Mayer, 2019; Khacharem et al., 2020; Sauli, 2018; Schroeder and Cenkci, 2018;). However, very few studies investigated the effects of the combined method of Andragogy and CTML. Thus, the study filled the vacuum niche of incorporating two evidenced-based learning theories into self-paced technological training programs.

This study was based on two of the scientific learning theories that exert significant value in education: (1) Knowles's (1989, 2015, 2020) Andragogy and (2) Mayer's (2003, 2020) cognitive theory of multimedia learning. Knowles's andragogy indicates that (a) Adults need to know the objective of learning a subject matter prior to undertaking its learning; (b) "Adults have a self-concept of being responsible for their own decisions and for their own lives, which helps them to make the transition from dependent to self-directing learners"; (c) Adults participate in learning activities with a great reservoir of life experience and new information is processed

through the lens of life experiences; (d) As adults mature, they tend to learn knowledge associated with their particular social roles and developmental tasks; (e) “In contrast to children’s and youths’ subject-centered orientation to learning (at least in school), adults are life-centered (or task-centered or problem-centered) in their orientation to learning; and (f) It is the intrinsic motivation that drives adults to learn, despite the responsiveness to external incentives (Knowles et al., 2020, pp. 44-46).

The researcher of this study drew on the Andragogy principles and the CTML to shape the design, development, and evolution of self-paced online learning. Strategically incorporating Andragogy allowed the researcher to build a sustainable and flexible technical training programs for learners in higher education. Incorporating CTML principles enables the learners to eliminate this extraneous processing and thus make the best use of the limited processing capacity to process the information relevant to the instructional goals.

The purpose of this study was to investigate the effectiveness of the combined method of Andragogy and CTML in enhancing learning results and optimizing students’ learning experience in an asynchronous Excel training program in higher education. The researcher designed a conventional Excel training for the control group, which included video tutorials, exercise files, and text-based handout and an Andragogy and CTML enhanced training for the treatment group, which included video tutorials, simulated hands-on activities, and visual-based mind map handout. The learning experience for both groups was designed on Storyline 360, an industry-standard eLearning authoring tool. A SCORM package, exported from Storyline 360, was uploaded into Canvas, the learning management system that the university has been using for years, for students to take the self-paced training at their own convenience.



This study was important because it this study filled a gap in the literature investigating the effect of the Andragogy and CTML-enhanced T&D training model on students' learning outcomes and learning experiences. This study also exerted significant practical implications as it will (1) help educational practitioners to effectively utilize the andragogical principles to address the unique contextual obstacles of young adult learners in online learning settings; (2) inspire educational practitioners with new insight into integrating instructional initiatives grounded in multimedia; (3) inform the educators of a theory-grounded framework to design effective online technical capability building solutions that are centered in the needs of learners; (4) provides institutions with effective training strategies that are transferable, economical, re-usable, and scalable.

## **CHAPTER II**

### **REVIEW OF THE LITERATURE**

*“Learning theories aren’t like religion.”*

*-Allison Rossett*

#### **Introduction**

The waves of transition driven by technology have happened at an unexpected speed in both the educational sector and cooperation. Training and Development (T&D) in higher education aimed at advancing stakeholders' technological literacy plays an important role in developing students' 21st-century competency (Ilonga et al., 2020; Sim et al., 2020; Gelles et al., 2020). It enables students to use technology as an effective tool to perform academic tasks. Further, T&D bridges the gap between education and employment by preparing students with the technical skills necessary for the 21st-century workforce (Percival, 2018).

Although online T&D could play an important role in closing students' technical learning gaps and preparing them for the workforce, the impact of their design, delivery, and evaluation on students' academic performance and workforce competitiveness has been investigated rarely. Moreover, there is a lack of studies focusing on the incorporation of scientific learning theories into the emergency e-learning design during unusual situations like a pandemic.

The current study responds to this need by (a) introducing a new online T&D program based on the integration of two learning theories, i.e., *Andragogy* and *cognitive theory of multimedia learning (CTML)*, into e-learning design; (b) investigating its impact on enhancing knowledge retention and skill transfer of university students and optimizing students' learning experience regarding learning motivation, autonomy, and satisfaction. The results of this study will exert both academic and practical implications for stakeholders such as researchers, teachers, students, instructional designers, educational administrators, educational policymakers, educational institutions, and corporations.

Related to the purpose of this study, in the following first an overview of online learning in higher education, its opportunities, and its challenges are provided. Next, the literature for integrating the andragogical and CTML models into online learning will be reviewed respectively. Next, mixed-methods T&D will be reviewed in the literature. In the last section of this chapter, a review of the literature assessing the effectiveness of a learning program in improving the students' academic performance and their learning experiences will be provided.

In this chapter, the author covered two sections that are related to the purpose of the study: Andragogy and Cognitive Theory of Multimedia Learning (CTML). The first section contains three subsections: (a) online learning, which reviewed literature that elaborates on the advantages and disadvantages of online learning. This section also describes the need of implementing

Andragogy into online learning, (b) Andragogy principles, which are aimed at transcending online learning in higher education, and (c) the effectiveness of applying Andragogical model in the higher educational setting. The second section reviews literature that incorporates the Cognitive Load of Multimedia Learning (CLTML) in online education, followed by the literature that validated the effectiveness of this method on learning outcomes.

### **Online Learning in Adults' Higher Education: Opportunities and Challenges**

With the ubiquitousness of technology and the internet, online learning has gained popularity globally and online teaching has mushroomed as a viable alternative delivery for institutions worldwide. Students taking online courses or degrees are one of the fastest growing populations in higher education institutions. A continuous growth trend that led to 5.8 million online courses across the country in 2016 (Yarbrough 2018), indicates that online learning is one of the preferred learning approaches by the increasing population of adult learners. Moreover, an analysis of existing online-learning research by the U.S. Department of Education (Cited in Stansbury, eSchool News, 2009) revealed that students who took part or all their classes online on average performed not just as good as but even better than those taking the same course through traditional face-to-face instruction.

Gerbic (2006) compared the strengths and weaknesses of face-to-face and online learning in addressing learner needs in terms of three major areas of visual/oral cues, response time, and oral/text-based communication (Table 1). From this table, it is evident that both approaches are not without concerns and criticisms, and further, they both have strengths and weaknesses. The adaptation of online teaching and learning is mainly implemented synchronously and asynchronously. Both ways lead to positive outcomes that make it a viable delivery system worldwide in all educational settings, including higher education. Previous literature indicated a

growing flourishing of online education due to its advantages such as convenient access to education and training, cost-effectiveness, time-effectiveness, and positive attitude toward the new learning platform, etc. Notwithstanding, studies revealed disadvantages and obstacles learners experienced in online learning such as loss of concentration and motivation, distraction, time management, poor interaction, etc. These challenges for educators to deliver quality education drew extensive attention and thus drove new innovations in online program design.

**Table 4**

*A comparison of face-to-face and online instruction approaches.*

	Face-to-face	Online
Visual/Oral cues	<ul style="list-style-type: none"> <li>• A rich nonverbal communication environment</li> <li>• High levels of monitoring and feedback</li> <li>• Conversation is competitive and requires confidence, especially to disagree</li> <li>• It is easier to build rapport and trust</li> </ul>	<ul style="list-style-type: none"> <li>• A more impersonal medium with reduced social cues</li> <li>• Messages are more difficult to understand</li> <li>• There is less social togetherness</li> <li>• Free to communicate for some participants</li> </ul>
Response time	<ul style="list-style-type: none"> <li>• Synchronous</li> <li>• Rapid spontaneous and free flowing dialogue</li> <li>• Fixed time and place a particular time and place</li> </ul>	<ul style="list-style-type: none"> <li>• Both synchronous and asynchronous</li> <li>• Asynchronous is more common</li> <li>• Space to reflect and think at one's own pace</li> <li>• No time and distance barriers, anytime, anywhere</li> <li>• Often takes more time</li> </ul>
Oral/text-based Communication	<ul style="list-style-type: none"> <li>• The emphasis is on listening and talking</li> <li>• Communication is quick and easy for confident speakers</li> <li>• Brief and short-lived</li> </ul>	<ul style="list-style-type: none"> <li>• The emphasis is on reading and writing, so there is a record</li> <li>• Messages/responses are often carefully thought out and written down</li> </ul>

- 
- Participation takes time
  - Can increase overload
- 

### **Prominent advantages of online learning**

Previous literature indicated the momentum growth of online education due to its unneglectable advantages. The primary advantage of online education is rooted in *the flexible access to learning resources* that breaks down the temporal and spatial barriers and allow the learning transaction anywhere, at any time, and at learners' own pace (Maqableh and Alia, 2021; Panigrahi et al., 2018; Pei and Wu, 2019). Maqableh and Alia (2021) reported that 73.9% of the students found online courses offer more convenient access than face-to-face courses. The offered flexibility of online learning is particularly attractive for adult learners as they would be able to maintain employment and family responsibilities (Parker et al., 2011).

Another advantage of online learning features its *cost-effectiveness*. Online learning improves the cost-effectiveness for both institutions and learners (Pannen, 2021; Maqableh and Alia, 2021). It provides a new platform for institutions and educators to reach out to more students and increase the learning opportunities and for students to develop necessary skills more flexibly. Compared with face-to-face courses, online courses could reduce tuition fees, transportation costs, and material expenses by 25 % (Dung 2020).

*Time-effectiveness* of online learning is another factor that drives its popularity among adult learners. Previous literature indicates students saved preparation and commuting times in online learning environments (Dung 2020; Hussein et al., 2020; Fidalgo et al., 2020; Panigrahi et al, 2018). Maqableh and Alia (2021) further support this agreement and indicates that 80.1% of students referred that online learning saved time commuting and 70.7% saved time getting ready for the learning. This is consistent with Dung (2020), whose study indicates that students in higher education appreciated online learning as it allows them more extra time for self-study. The

availability of learning materials anytime anywhere and especially the use of asynchronous communication tools increases the time that students spend on their tasks. This could allow the students for a deeper engagement with the learning activities. The self-paced learning in asynchronous format allows and encourages students for reflective learning and as a result a higher level of cognitive transactions.

In addition to the improved access, cost-effectiveness, and time-effectiveness, the growing prevalence of online learning is also attributable to the *positive attitude toward the new learning platform*. Online education provides a new platform for educators to enhance the quality of teaching and learning to accommodate the various learning styles of students (Pannen, 2021). Students recognize online learning as an experience that features exposure to new and interesting forms of learning (Dung, 2020).

Despite these advantages of online education and the positive experiences of many learners, there are many students who expressed obstacles to learning online, which caused dissatisfaction with this educational format. Previous literature reveals that the most important factors behind the students' dissatisfaction during online learning are distraction, time management issues, motivational challenges, and lack of interaction with classmates. These factors remain key challenges for delivering engaging learning experiences and quality education in online educational settings.

### **Prominent disadvantages of online learning**

Although online learning emerged as an alternative to overcome the disadvantages of the face-to-face delivery, it may not be holistically accepted yet as an effective alternative for certain inherent issues surrounding purely online instruction as will be discussed in the following.

*The lack of human interaction.* Poor interaction remains an important limitation that impacts online learning satisfaction. Pure e-learning is perceived as ‘isolating’ without any human interaction and does not fit well with the ethos of the campus-based higher education institution where success in student learning is based on, among others, the instructor’s ability to perceive nonverbal student cues, modify instructional methods accordingly, and provide timely responses to student questions. Laurillard (1997) argues that although the extent of student interactions in online courses may surpass those in traditional classroom courses, research has shown that the quality of online learning suffers from the lack of human interaction. Moore (1989) defines three types of online learning interactions: interaction with the instructor, interaction with classmates, and interaction with learning content. Consistent interaction with the instructor facilitates deep learning in online education (Mu and Wang, 2019) and enhances students’ learning engagement and experience by creating a positive psychological atmosphere (Sun et al., 2022). Sustained interaction with classmates allows learners to share ideas, deepen their understanding of the subject matter, re-construct course concepts, obtain peer support, and thus lead to the more relevant application of the newly acquired knowledge. Interaction with the content is the process of intellectually processing the course information, which can change a learner’s understanding and perspectives (Moore, 1993). Despite the importance of interaction in the learning process, previous research suggests there is a lack of interaction in online education (Duang, 2020; Kalman et al., 2020). A survey study conducted by Duang (2020) reports that 75.6% of students pointed out the disadvantage of lack of peer interaction in online courses. Maqableh and Alia (2021) finds that only 30.1% of students are satisfied with their interaction with colleagues.

Previous studies point out that *distractions* such as mind-wandering and multitasking exist as another utmost disadvantage of learning online. Maqableh and Alia (2021) reports that 84.8%

of students find themselves get distracted easily in online courses in the early stage of online learning. This is in line with Duang's (2020) report that 93.6% of students experienced extensive time staring at digital screens and 78.2% suffered from concentration loss. Another distracting factor is rooted in the multitasking feature of digital devices, which allow users to run multiple applications simultaneously, and even lure students to do off-task activities during class. Previous literature suggested a detrimental effect of media multitasking activities on students' academic performance in online learning (Dontre, 2021; Hall et al., 2020; Hayashi and Nenstiel, 2019; Mendoza, et al., 2018; Parry et al., 2020).

Another disadvantage of learning online that students complained the most is the difficulty of *maintaining motivation*. External factors such as limited connection with the instructors and distracting learning environment at home have greatly impaired students' motivation. This is in accordance with Maqubleh and Alia (2021), which found that 72.1% of online learners feel less committed due to the absence of instructors and 43.3% spend less time for study than they do in traditional face-to-face classes. Students with a lack of motivation in online learning were greatly affected by external factors, including (a) missing positive encouragement of attitude and verbal inspiration from the instructor; (b) lack of practical context of integrating newly acquired knowledge to perform real-world tasks (Yustina et al, 2020); and (c) feeling of being isolated (Gustiani, 2020).

Studies indicate that *time management difficulty* is another utmost obstacle to online education. Time management is an essential skill for learning achievements and other life activities. To achieve desired learning results, learners are expected to commit time to course content, group discussion, project execution, course examination, and other learning activities. While online learning is accessible at home, the boundary between learning engagement and other



home activities has been obscured. As a result, learners encounter a problem balancing studies, families, and personal life activities. As for those who have full-time or part-time jobs, sequencing online learning into their busy life is even more challenging. According to Danchikov et al. (2021), almost half (48%) of the remote learners had time management difficulties. This report is consistent with Rafique et al. (2021), which indicated that online learners felt they had less control over their learning environment and time management.

*The constraint of limited resources (financial hardware, and software constraints)* is another shortage of online learning. Although e-learning has been found successful in some developed countries with a certain type of learners, their use in developing countries requires supplements for success due to poor infrastructure including limited telephone connections, poor Internet bandwidths, shortage of trained personnel, and limited computer skills among both teachers and students. Most of the Information and Communications Technology [ICT] infrastructure is limited to capital cities and major centers and is unavailable to the great majority of rural and remote area dwellers, leading to uneven access (Sagna, 2005). Besides, some courses (e.g., engineering courses), no matter how well designed, will need face-to-face and hands-on components to be effective and successful.

Currently, the most common and widely used approach to maximize the strengths and minimize the weaknesses of online learning is to combine the best features of conventional face-to-face instruction and online learning through so-called hybrid or blended learning (e.g., Duhaney 2004; Serrano et al. 2019; Alamri et. al. 2021). However, rare studies have investigated other approaches for improving online learning experiences based on the incorporation of well-known learning theories such as Andragogy, CTML, and particularly their combination.

### **Integrating Andragogy into Higher Educational Setting**

Another way to ensure quality learning is to maintain an online educational experience with a foundation in adult learning theory. According to several studies, adult learning theory is not solely limited to one particular field of study or even the classroom context. It has been used in almost any context where an adult may be conceived as a learner, including business, education, religion, athletics, and law (e.g., Henschke, 2004; Lubin, 2013; Shostak, 2019; Shostak et al., 2022).

As an individual learning transactional framework rooted in humanistic and pragmatic philosophy, Andragogy can be an effective way to transcend online learning and teaching in higher education. To mitigate the disadvantage of online learning for young adult learners in higher education, numerous researchers proposed to consider the learning characteristics of adults (e.g. Tezcan 2022; Shostak et al., 2022). Tezcan (2022) suggested educators integrate Andragogical principles in the online learning environment such as in certificate programs. Shostak et al. (2022) claim that “faculty across disciplines turn to Andragogy to best teach college students and to ensure maximum learning takes place under these new circumstances.” In order for educational institutions to deliver the ideal education to adult learners, it is necessary to consider the affective and cognitive aspects by applying Andragogy (Panta-Merino and Centurión-Cabanillas, 2021).

This section details Andragogical principles. Further, it discusses the effectiveness of incorporating Andragogy in online programs in higher education as investigated by previous studies.

### **Andragogy Principles**

*Andragogy* (Knowles, 1968, 1980) manifests constructive learning theory by considering the involvement of adult learners in their own education. As a learning transactional model, Andragogy provides a scientific insight into how adults learn in contrast to children. It can be used

in almost any context to provide adult learners the opportunities to be self-directing, an important advancing need that comes with maturity (Henschke, 2004; Lubin, 2013; Shostak, 2019). However, Andragogy is not a direct antithesis to pedagogy and itself includes some pedagogical assumptions as in some learning contexts they could be more realistic regardless of the learners' age (Knowles, 1984, p. 62). Although not an exhaustive list of characteristics of adult learners, there are six assumptions that constitute the foundation of the Andragogical model:

1. *The need to know.* Adult learners need to know why they need to learn something before undertaking the learning (Knowles et al., 2020, p. 44). Therefore, one of the first tasks of the facilitator of the adult learning programs is to inform the adult of the value of learning a particular lesson and the negative consequences of not learning it. The facilitator can elaborate on the competence, skills, and knowledge that learners will obtain and explain how the learning will improve their work performance and life quality. A more effective tactic for facilitators to leverage learners' consciousness of the need to know is to allow learners to self-discover their own gaps between where they are now and where they want to be. This could lead to self-direction. Clear learning objectives, future job opportunities, performance reviews, and exposure to role models are examples of such tactics.
2. *The learners' self-concept.* Adults have a developed self-concept of being responsible for their own decisions in their lives (Knowles et al., 2020, p. 44). With a deep need of being self-directed rooted in their hearts, adults actively take initiative to control their own life. They refuse to accept the wills imposed by others. Therefore, the instructional facilitators need to treat adult learners as self-directed learners who are active participants in self-directed learning. Loeng (2020) defines self-directed learning as a process "by which individuals take the initiative, with or without the assistance of others, in diagnosing their

learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.” As the adult education practitioners are aware of these characteristics, Knowles et al. (2020, p. 44) suggests they “make efforts to create learning experiences in which adults are helped to make the transition from dependent to self-directing learners”.

3. *The role of learners’ experiences.* Adults participate in learning activities with a great reservoir of life experience (Knowles et al., 2020, p. 44), which is a valuable resource for the learner and their peer cohort. New information is processed through the lens of life experiences. The Facilitators should tap into the experience of learners, highlight the applicability of their experience, and allow the course content to evolve. Case studies, group discussions, problem-solving activities, and collaborative assignments should take place of the tightly scripted content. By emphasizing the rich experience of the heterogeneous learners, the facilitators are creating not only a collaborative, friendly, and open learning climate, but a community of new perspectives and fresh ideas.
4. *Readiness to learn.* Adults become ready to learn in order to cope effectively with real-life situations (Knowles et al., 2020, p. 45). Their *readiness to learn* is closely associated with the developmental tasks of their social roles. The *readiness to learn* varies as they move from one life stage to the next. Adults’ *readiness to learn* is often triggered by certain changes or situations in their lives. They tend to learn something that has immediate relevance and application in real-life situations. For example, a graduate student who anticipates landing a job becomes ready to participate in interview workshops. An engineer tends to learn leadership skills when given a promotion to lead a team. The triggers are not necessarily tightly associated with a certain age or within phases in the lifespan (Tønseth,

2015). Thus, instead of passively waiting for the readiness to develop naturally, Knowles et al. (2020, p. 45) indicate that “there are ways to induce readiness through exposure to models of superior performance, career counseling, simulation exercises, and other techniques.” The implication of this principle for educators is to provide relevant instruction that coincides with adults’ functional tasks in their social roles.

5. *Orientation to learning.* Instead of subject-centered pedagogical learning, adults’ orientation to learning is life-centered (or task-centered or problem-centered) (Knowles et al., 2020, p. 45). Adults are motivated to learn new skills and knowledge that are highly relevant to a task and help them to solve real-world problems. Tokuhamma-Espinosa (2011, p. 218) provides neuroscientific insights that buttress this assumption: “the human brain learns best when facts and skills are embedded in natural contexts of concrete examples, in which the learner understands the problems he or she faces and recognizes how the facts or skills might play roles in solving that problem.” The *orientation to learning* assumption exerts significant practical implications for adult education. Knowles et al. (2020) indicate that instead of dividing learning into subjects, courses should be divided into real-world situations. Ferreira and Maclean (2018) suggest a problem-based learning curriculum, which can be paired with technology to connect learners with audiences around the world. In order to further leverage learners’ *readiness to learn*, online facilitators can incorporate assignments that allow participants to discuss practical applications of a theoretical concept. Real-life cases and concrete examples can motivate adult learners as the context of application is materialized.
6. *Motivation.* It is the intrinsic motivation that drives adults to learn, despite the responsiveness to external incentives (Knowles et al., 2020, p. 46). In contrast with

children's motivation which is heavily reliant on external variables, adults are "heavily driven by self-esteem, social status, and self-satisfaction" (Knowles et al., 2020, p. 46). They are self-motivated to learn new skills, knowledge, and concepts that are practically relevant to their work situations and life stages. Neuroscience research provides additional support for this assumption and indicates that positive emotions increase the release of neurotransmitters, which plays a key role in the information processing of the brain (Immordino-Yang et al., 2018). In light of this principle, Andragogical facilitators should provide well-defined milestones and timely feedback and show appreciation for learners' contributions. Drawing on learners' background and experience is also beneficial in terms of evoking adults' motivation.

These principles characterize how learning design approaches for adult learners differ from those for children. Such educational design can encourage willing and meaningful participation that could ultimately result in achieving desired learning outcomes. Hence, Andragogy is an effective model for teaching and learning as it buttresses two of the essential principles of learning: (a) the usefulness of the material for the learners and (b) the active participation of the students (Seaman and Fellenz, 1989).

### **Effectiveness of Andragogy**

The number of adult learners in higher education - defined in this study as students aged 18 or older - has been growing rapidly during the past decades. Adults learn differently from children due to their more complex background knowledge, responsibility, and life experience (Malone, 2014). In terms of the age period of the participants, the level of higher education is a part of adult education, and there are many studies that evaluated young adults within the scope of adult education and learning (Kasworm, 2018; Toiviainen et al., 2019). As a matter of fact, studies

on young adults at the level of higher education have shown that the tendency toward learner-centered Andragogy has increased dramatically in the last two decades (e.g., McNally et al., 2019; Santos et al., 2019; Livingston-Galloway and George, 2020). Accordingly, the adoption of Andragogical approaches in educational activities and learning environments from the beginning of young adulthood, which is also the first period of adulthood, positively affects learning by increasing participation and interest.

Previous literature has investigated learning programs grounded in Andragogy in higher education settings and has informed a eureka of discoveries regarding the validity and effectiveness of Andragogy in terms of (a) supporting students' professional goals; (b) reducing learners' anxiety in the application of the subject matter, and (c) facilitating self-directed learning.

First and foremost, utilizing Andragogy as a framework has a pivotal role in *supporting the professional goals of university students*. Roe (2022) conducted an interpretive phenomenological analysis to explore the relationship between service-learning and career preparation using Knowles' Andragogy as a theoretical framework. She applied at least four of the six principles of Andragogy to the service-learning context in graduate education, which led to a learning experience be extensively self-directed and problem-centered and offered direct experience related to students' social roles as early-career professionals. The researcher found that integrating Andragogy in the service-learning program for the young adult learner is (a) a professional experience itself and an opportunity to further prepare for graduate school students' future careers and (b) a genuine way for students to develop skills and self-efficacy important to their career trajectory. This finding is in line with studies by Ring et al., (2019) and Sato et al., (2020) which indicate that an Andragogical-based program transforms both participants' professional lives and the professional service they provide.

Additionally, employing Andragogy has statistical significance in *reducing learners' anxiety* in the application of a subject matter. Grandy (2019) studied levels of library anxiety in 30 adult learners before and after completing a two-credit hybrid Research and Information Literacy course (RIL). Using Andragogy as a framework, the RIL professor integrated self-directed learning material (lectures, readings, and videos) and activities (group discussions, problem-solving practices) into the curriculum, which is in line with the *learners' self-concept* and *orientation to learning* the Andragogical model. Students were encouraged to use their own research topics in a practical exercise, which aligns with *the role of learners' experiences* assumption of Andragogy. In the light of the *need to know and orientation to learning* of Andragogy, the practical relevance of the course concepts to students' lives relevant to their jobs, families, or communities was also highlighted. The t-test analysis of the multidimensional library anxiety scale administered at the beginning and end of the course indicates that the course was moderately effective in reducing library anxiety in adult learners. The awareness of library resources, comfort with the search process, and comfort level with library technology significantly increased after course completion.

Further, an Andragogical grounded instruction has shown a positive impact in *enabling university students to be self-directed learners*. As preparatory skills for learning success, the ability to competently self-manage study is a competency that “students must learn and master, along with any specific subject-based content” (Dant et al., 2021; Mann and Willans, 2020). In higher education, this is when a student: “is mindful of and asserts control over their own thoughts; can understand what is required to plan their learning; has a metacognitive understanding of their actions while engaged in their study; and has the knowledge and tools to evaluate and revise their study habits and plans” (Mann and Willans, 2020). Previous literature shows that instructions



grounded in the theoretical framework of Andragogy develop students' learning autonomy, which has the potential to benefit all the subject matter learning in higher education. Mann and Willans (2020) found that “students were able to learn how to become self-directed learners when lecturers ‘tailored’ teaching to the student's needs, taking into consideration their state of mind, ability to plan their work, developing adeptness at engaging in mathematical activities, and assistance received in evaluating their own learning outcomes”. The study of Lewis et al., (2018) supported this finding and indicated that a flipped classroom grounded in adult learning theory fostered self-directed, active learning, and deeper learning in the third-year surgery clerkship.

Last but not the least, previous research indicates that applying the adult learning method in the classroom is beneficial to students in that it *nurtures their critical thinking, effective teamwork, and interpersonal communication*, which have become indispensable skills in both academic and professional settings. Livingston (2020) suggested that “pedagogy can steer students’ mastery of specific subject content, but it does not necessarily build skills, abilities, and attitudes, and it does not measure a learner’s sequential practice in cognition, affective, and psychomotor skills. In contrast with pedagogy, which may “limit the development of critical thinking skills” (Livingston, 2020), Andragogy has been believed to be effective in developing learners’ skill sets in critical thinking, effective teamwork, and interpersonal communication (Livingston, 2020). Livingston (2020) suggested that applying Andragogy in higher education would result in great significance and he further proposed to implement Andragogy in Radiologic Technology Education, in order to prepare competent and effective entry-level radiologic technologists for present-day practices.

### **Andragogy in Online Learning**

It is important that the designers of online learning environments for adults understand and apply the adult learning theory in terms of its relation to online learning (Cercone, 2008). However, studies of the effectiveness of incorporating Andragogical principles into online learning are scarce. Although the term Andragogy might not be used, self-directed learning methods are commonly used in online instructional designs. This is due to the fact that the techniques that are used for engaging adult learners and online learners are similar. The best practices for e-learning include: (a) making lessons highly relevant to the learners' goal (Park and Choi, 2009), engaging learners through problem-centered exercise (Tsai, 2013), and establishing opportunities for reflection and collaboration (Cheanyey and Ingegriksen, 2005). "Gaming Instructions" are another growing trend in online learning that support Andragogical model (Kim, 2012). This approach allows learners to inspire curiosity, work at their own pace, and apply the information literacy skills directly to the learning goals of a course (Martin and Ewing, 2008).

Aziz et al., (2014) presented a framework for integrating an instructional design model (i.e., ADDIE) and Andragogy model into the multimedia e-content development process. They attempted to distinguish the characteristics of learning materials that suited best the adult learning needs in an online environment and provide some basic recommendations and design guidelines. They provided some suggestions collecting required data for a quantitative evaluation of learning material applications using questionnaires and pre-and-post tests. However, no case-study result was provided.

Halpern and Tucker (2014) examined the incorporation of adult learning theories into the design of online tutorials for a university library using the Storyline platform and informed by Knowles' theory of Andragogy. More specifically they applied four principles of Andragogy models into their online instruction. To incorporate the first principle of Andragogy, *the need to*

*know*, they framed the structure of each tutorial and placement of each module within the curriculum within a required skill set using various digital learning objects. In this design, each tutorial begins with a small story about the covered concept in which the story is an example of a fictional situation in which a learner faces difficulties to complete an assignment due to the lack of skills presented in the tutorial. This is an effective method to let learners better understand why a certain skill is useful for them. Storytelling is a powerful learning tool that let learners put themselves in the middle of a problem (Clark and Rossiter, 2008). To apply the second principle, the authors modeled problem-based learning by embedding an activity that needs to be completed or a problem that needs to be solved in each slide. To acknowledge *the learners' prior experience*, the third principle, an opportunity was provided for the learner to reflect on their experiences and apply them to the covered materials. The fourth principle was applied based on the self-directed learning strategy (Merriam, 2001) and through navigation options. Students are free to use the menu to navigate to their needed materials. Although in this study the researchers demonstrated how Andragogy can be applied to nearly any digital learning subject, they did not assess the effectiveness of their approach and only some survey results were provided.

Aziz et al., (2016) studied the effectiveness of multimedia instruction materials that are specifically designed and developed for adult learners. The researchers integrated nine events of instruction from Gagne's learning theory (Theng and Mai, 2009) into the design of multimedia content for online learning with assumptions of Knowles's Andragogy in mind. Their pre and post-tests on 50 participants revealed that provided multimedia materials were useful for the adult learners.

### **Justification for the Study**

Knowles' Andrological model provides a scientific insight into instructional design, especially for online programs. Learning experiences that encourage motivation and meaningful participation can contribute to achieving desired learning outcomes collectively and individually. Despite the wealth of literature on improving adult learners' experiences through their engagement in face-to-face instruction, few studies have focused on integrating Andragogical principles into asynchronous online learning. Moreover, there has been less work investigating the effectiveness of such incorporation through a mixed-method experiment design. The researcher believes a training solution should work with students' schedules, engage students, develop the in-demand skill to solve real-world problems and prepare students for their future roles. The presented framework in this study can help educators to design effective online technical capability-building solutions that are centered on the needs of learners.

### **Integrating CTML into Online Higher Educational Setting**

Multimedia is the presentation of materials in form of pictures and words that focuses on the visual/pictorial and verbal/auditory channels. It is playing an ever-increasing role in education with the advancement of Information and Communication Technology (ICT). The goal is to provide a learning environment powered by multiple formats, such as image, text, video, animation, and audio presentation (Moos and Marroquin 2010). Compared with media that only uses a single information processing channel (auditory or visual), the usage of multimedia can improve learning (e.g., Mayer, 2008; Rolfe and Gray, 2011; Noetel et al., 2021). This can particularly benefit learners with low prior knowledge of a topic, and it suits well for the teaching of complex materials at a faster speed (Lucas and Abd Rahim, 2017).

Despite the key roles of multimedia in enhancing outcomes and experiences in modern education, the extent and quality of their usage in a course or instruction could have diverse effects.

As an example, the usage of too much multimedia could interfere with the ability of a learner for absorbing information and result in decreasing learning effectiveness. On the other hand, contents that contain high interactivity among their parts can not be delivered effectively through a weak learning design in which extra processing by students is required. Thus, learning improvement occurs only when multimedia has been used effectively and been implemented based on theoretical frameworks. The poor design and implementation of multimedia can result in needless distraction, cognitive overload, and/or poor learning (e.g., van Merriënboere and Sweller, 2005; Mayer, 2008, 2009; Sweller et al., 2019).

Mayer (2003) stated that the benefit of multimedia usage highly depends on how a course, or an instruction is designed and delivered, thus understanding the cognitive processes and mechanisms of learning through distinct channels could guide us for a better design of e-learning materials and results in a general improvement in learning experience/outcomes. Multimedia learning or “learning from words and pictures” (Mayer 2014, p. 1), is a multi-stage cognitive process of forming a mental model based on pictures and texts presented to a learner (Eitel et al., 2013). Learning is an active mental process, in which a learner selectively attends to presented materials, extracts and organizes coherent mental representation, builds connection with relevant prior knowledge that is retrieved from long-term memory (Mayer, 2014).

Mayer (2020) articulates pre-training in the realm of multimedia learning as a process that equips the learner with prior knowledge that will make it easier for the learner to process the presented material. Specifically, Mayer's definition of pre-training is a general one that involves providing students with the names and characteristics of the main concepts of a lesson. Mayer's definition is drawn from the Pre-Training Principle of Multimedia Learning which indicates that

people learn more deeply from a multimedia message when they are provided the names and characteristics of the main concepts of a particular topic (Mayer, 2020).

From a theoretical perspective, Mayer and Moreno (2003) note that when a material is particularly complex or the material is presented at a fast pace, the learner may not have enough working memory space to engage in effective processing. Thus, arming students with the names and characteristics of the topic to be studied, will make it easier for them to process complex information by facilitating schema formation in the working memory.

### **Mayer's cognitive theory of multimedia learning (CTML)**

The Cognitive Theory of Multimedia Learning (CTML) was presented as a theory of multimedia learning in terms of an information-processing model (Mayer, 2001, 2003, 2005). CTML has major applications in the online-learning design for reducing the cognitive load and facilitating active processing. It offers a set of empirical guidelines to elevate instructional design and as a result, obtain meaningful learning.

Mayer (2001) put the foundation of his theory on cognitive science and three key assumptions of dual channel, limited capacity, and active processing. Cognitive scientists explain that in the process of making sense of new learning material, learners apply a sequence of cognitive processes. In the first step, they select some parts of the presented visual or verbal information and transfer them from their sensory memory to their working memory. Meaningful learning occurs in the working memory where learners select and organize the relevant information in each store to form a coherent representation of the external materials that they were exposed to and then connect these coherent representations across different stores (Chambliss and Caffee, 1998). Learners form connections between new and stored knowledge by bringing the stored knowledge from their long-term memory into their working memory (Mayer, 2001). The primary demand in this process is

on the limited capacity of working memory. Thus, the learning of an individual will be affected if a learning task exceeds the capacity of his/her limited working memory (Kinshuk, 2015). Mayer's solution to this limitation (i.e., CTML) is the optimal use of two visual and auditory channels (Mayer, 2014) and the reduction of cognitive load (Mayer and Moreno, 2003; Huang et al., 2016).

Based on this, he listed five cognitive processes that a student needs to take for meaningful learning in a multimedia environment (Mayer, 1999): (a) the selection of relevant words for processing in verbal working memory; (b) the selection of relevant images for processing in visual working memory; (c) organizing selected text base into a verbal mental model; (d) organizing selected image base into a visual mental model; and (e) integrating verbal and visual representations. Understanding these sequential processes helps to have a constructivist design of instructional materials.

These foundational concepts and assumptions lead to a set of design principles of CTML that could increase the material transfer and retention in a multimedia learning environment (Mayer, 2001). In the following, we briefly review some of the main principles that are closely related to the purpose of this study:

1. *Multimedia principle*. Mayer (2001) noticed that when graphics and text are combined learners' retention increases by 42 % and when the text is presented verbally rather than visually student retention increases by 30 %. This leads to the principle of multimedia (or multiple representation principle) which states presenting an explanation in words and pictures is more effective than only in words.
2. *Spatial contiguity principle*. It is more effective to present pictures and words in the vicinity of each other rather than at a distance on a screen or page.

3. *Temporal continuity principle.* It is preferred to present corresponding words and pictures simultaneously rather than successively. Contiguity principles (i.e. spatial or temporal) facilitate the learning process by helping the learner to focus on the most useful materials and connect relevant contents.
4. *Coherence principle.* It is more effective to use few words and highly relevant pictures rather than many superfluous ones. This principle suggests avoiding content that could distract learners from the core content essential for a task which is a strategy to reduce extraneous load.
5. *Modality principle.* Students learn more easily from pictures and narration than from pictures and text. Concurrent presentation of textual information in an auditory mode and visuals leads to better knowledge acquisition by students (Ginns, 2005; Mayer, 2009) and a deeper understanding (Mayer, 2003; Mayer and Sims, 1994; Paivio et al., 1998). This principle recommends that two messages on similar elements be provided through different sensory modalities. The utilization of the multimodality approach helps students to learn by linking different modalities and avoiding an overload of information in the visual processing channel (Van Someren et al. 1998). When dual modalities are used, more memory capacity would be available, however, there can be the risk of the split-attention effect - i.e., when the student's visual attention is split between two tasks of watching animation and reading the related texts while neither of these alone suffices for understanding (Sweller, 1999).
6. *Redundancy principle.* The learning performance decreases as redundant materials are presented in more than one form (for instance when students see and hear the same verbal message). Thus, it is better to remove repeated learning materials guided by the relative



effectiveness of multimedia (e.g. a narrated animation would be more effective multimedia for learning than a combination of animation, narration, and text).

7. *Individual differences principle*. The effects of e-learning designs are different for students with high and low knowledge as well as for distanced and in-class learners. Moreover, Conversational narrations are more effective than formal ones for some students.
8. *Signaling principle*. Highlighting the organization of the essential materials helps individuals to learn better. The signaling (or cueing) principle helps learners to direct their attention effectively to the most intrinsic materials and ignore the extraneous ones. Emphasizing a key point with a phrase or circling the key points in a video are some examples of signaling.
9. *Image principle*. Adding the image of a speaker to the screen does not improve learning in a multimedia environment.
10. *Voice principle*. Using a friendly human voice rather than a machine voice for narration in multimedia systems improves learning.
11. *Feedback principle*. A deeper understanding of a material can be achieved if some feedback on students' responses and assignments is provided.

These principles can be grouped into 3 main categories: (a) manager of essential processing (e.g., *modality principle*); (b) minimizer of extraneous processing (e.g. *redundancy principle*, *coherence principle*, *signaling principle*, *temporal and spatial contiguity principles*); and (c) facilitator of generative processing (e.g. *individual differences principle*, *multimedia principle*, *image and voice principles*).

However, these design principles do not always lead to the same learning improvements. There are a number of factors that could decrease or increase their effectiveness. For instance, there

are three situations in which the role of our limited working memory capacity becomes more distinct; (a) when the learning materials are more complex; (b) when more cognitive load is required for each concept especially due to their novelty; and (c) when the presentation format is harder to deal with. Good multimedia principles play a more crucial role in learning designs for novice learners, not self-paced learning, and for more complex concepts that have a high degree of interactivity among their elements (Mayer and Moreno, 2010; Sweller, 2010).

Moreover, learners' motivational requirements could play an important role in learning outcomes, and this is why they are often considered in the instruction designs to image the learners in a learning activity for its inherent enjoyment (Visser and Keller 1990; Gurland and Glowacky 2011) rather than a separable reward (Keller 2010; Ryan and Deci 2000). Schrader et al. (2018) suggested that individual motivational prerequisites need to be considered when multimedia learning activities are designed. Although Mayer's original CTML assumes equal motivations for multimedia learning among all learners, later Mayer (2014) also pointed out the importance of the incorporation of metacognition and motivation into multimedia learning design. This is what has been proposed in the cognitive-affective theory of learning with media (Moreno, 2005, 2006) to expand Mayer's CTML.

### **Effectiveness of CTML**

A considerable number of studies have indicated the effectiveness of multimedia learning for facilitating students' learning abilities like a higher order thinking ability (Mayer, 2003; Korbach et al. 2018). A review of 31 published papers on hyper video for multimedia learning indicated that the use of hyper video is beneficial for students' learning (Sauli, 2018).

CTML design principles have been adopted in many studies and there are hundreds of studies on the applications and effects of different multimedia design principles and a single

systematic review of all these primary studies would be impossible. There have been meta-studies examining the effects of individual CTML principles on learning. As an example, Schnieder et al., (2018) conducted a review of 103 peer-reviewed quantitative studies on the impact of *signaling principle* and found that out of 139 effect sizes 117 were positive in favor of *signaling principle*. Similarly, Alpizar et al. (2020) performed a meta-analysis of 29 experiments on 2726 participants and found a 0.38 effect size, with a statistical significance of  $p < 0.01$ , indicating the effectiveness of signaling in enhancing learning outcomes. The results of meta-analysis studies on the effects of the *spatial contiguity principle* imply its effectiveness for improving learning outcomes (e.g., Schroeder and Cenkci, 2018; Mayer, 2019; Khacharem et al., 2020).

Noetel et al. (2022) performed a systematic meta-review of 1,189 studies on 78,177 participants testing the effectiveness of multimedia design for cognitive load or learning to identify the best practices for multimedia design and how well CTML theory held up. They distinguished eleven design principles that were proven to have positive effects on learning and five principles that significantly improve cognitive load management. Captioning of second-language videos, *signaling*, and *temporal/spatial contiguity* have the largest benefits. They also found that good design was more crucial for more complex materials, and in system-paced environments than self-paced ones (such as websites).

These observations are in agreement with other studies (e.g., Schrader et al. 2018; Lai et al. 2019). As an example, in Moreno and Mayer (1999) the effect of the application of the *spatial-contiguity principle* in computer animation design on students learning retention and transfer was studied. They found that learners benefit from the verbal and visual materials with physical approaches. Similarly, simultaneous display of visual and verbal materials have been shown to be

an effective approach for enhancing the learning effectiveness of students with lower proficiency level (Türk and Er.etin, 2014).

Many studies investigated the effectiveness of *static versus dynamic multimedia* in learning outcomes and tried to answer whether or not additional factors such as *spatial ability* (e.g., Castro-Alonso, et al. 2019), *gender* (e.g., Saha and Halder, 2016), or *prior knowledge* (e.g., Grimley, 2007) have any added value. For instance, some studies reported higher learning benefits for female learners from animated materials (e.g., Coward, et al., 2012), while other studies suggested more benefits for males (e.g., Saha Halder, 2016; Heo and Toomey, 2019). Similarly, some researchers observed a higher learning gain for learners with a higher spatial ability (e.g., Coward, et al., 2012), while others suggested a higher learning gain among learners with a lower spatial ability (e.g., Hoeffler and Leutner, 2011; Münzer, 2015). While some studies suggested that animated materials have no benefit over static materials in terms of learning outcomes (e.g., Kim, et al., 2007; Vogel-Walcutt et al., 2010; Daly, et al., 2016), there are other research that reported positive learning outcomes using animated learning materials (e.g., Lin and Dwyer, 2010; Lin, 2011; Parette, et al., 2011; Yang et al., 2018).

Kuo et al., (2014) developed a multimodal presentation system (MPS) based on CTML to present multimedia instructional materials (verbal and corresponding visual materials) and manage interactive learning activities in the classroom. They explored the effectiveness of their system in improving the learning achievement and satisfaction of the elementary students in an English teaching class. They considered academic achievement (e.g., grades, test score) and overall learning satisfaction as criteria for measuring students' learning effectiveness and used post-test and a self-questionnaire for data collection and t-test for data analysis. Their experiment involving 134 students ranging in age from 11 to 12 and from six classes of two public elementary

schools in Taiwan revealed that the students who used the multimodal system (MPS) achieved better learning results and a higher level of satisfaction on average.

Chen (2020) studied the impact of *effective-motivational aspects* of instructional designs in multimedia learning. In this research, a game-based learning method using augmented reality [AR] was designed to assist students' learning by probing the metacognitive and motivational factors of multimedia learning. They compared the effectiveness of this combined approach vs individual approaches through an experiment involving 100 elementary-school students in Taiwan with an average age of 9.5 years old. The results of the pre and post-tests in this study indicate that there is no interaction between gaming and AR and both could significantly improve the students' learning motivations but the learning achievements only improved through the gaming approach.

Heo and Toomey (2020) studied the effect of *gender and the type of multimedia* resources on learning outcomes while controlling for the effect of spatial ability. They also tried to investigate the differences in learning outcomes between retention and transfer questions. With the participation of 245 undergraduate students, they investigated their research questions and concluded that gender difference exists, and spatial ability has more impact on learning outcomes. However, they did not find any influence of multimedia type on learning outcomes.

### **CTML and Online Learning**

Roy (2004) performed a preliminary study about the impact of self-paced multimedia design on the *modality effects*. More specifically, the practical issues in the design of a self-paced system consisting of narration modules and static graphics were discussed. Discussed issues mainly deal with the interaction of users for optimal coordination of the presented visual and auditory materials when they have the ability and freedom to do so. In a pilot test on 5 participants, he found the levels of accuracy and reading comprehension for modules, with or without narration,

result in a similar performance. It was also observed that learners prefer to use narration, task-based online tests, and graphics if a system permits self-paced interactions.

She et al., (2009) employed a model of instructional design (i.e., ADDIE) and CTML to develop a web-based multimedia course for teaching technical Chinese language in which pictures, sounds, videos, and Flash animations were integrated with an objective of optimizing the learning efficiency. However, no quantitative analysis of their experiment and findings were provided.

Baukal (2014) developed a conceptual framework for instructional design by combining Dale's Cone of Experience (Dale, 1969) and CTML. He used a survey of 118 working engineers from a Midwest manufacturer to explore the learning strategy and style preferences of the learners. His findings indicated that there might be an occupational profile for working engineers where their learning strategy profile was different than the general population in which there are fewer engagers and more problem solvers. Furthermore, this study suggested that working engineers are much more visual and prefer more graphical multimedia over textual ones compared to the general population based on analyzing their multimedia preferences. The T&D nature of the online learning in this study and adult participation make this study relevant to our proposed research.

Saad, et al. (2015) studied the effectiveness of incorporating CTML principles in the development of tutorials for children with intellectual disabilities. They experimented with two different approaches; a static (or pre-designed) technique and a dynamic one in which multimedia tutorials were automatically generated by querying for the desired topic based on semantic content analysis and ontology from the internet. Testing the proposed systems on 100 participants with an average mental age of 8 years and intellectual disabilities in Doha, they found substantial effectiveness of multimedia learning in increasing different aspects of the learning such as performance, scores, acceptance, and motivations.

Lucas and Abd Rahim (2017) analyzed the design characteristics of popular expository and instructional animations from online video streaming sites such as YouTube. In this study, CTML was used as an analyzing tool as it is based on extensive empirical studies of cognitive load theory (Mayer, 2009). The results of this study showed some common characteristics and unique approaches that can be used to create well-received instructional animations for online viewing.

Park et al. (2019) explored gender differences and whether and how the incorporation of multimedia technology in online learning is accepted and used by learners. They proposed a learning model in which the technology acceptance model is integrated with task technology fit theories. The developed model was tested by 120 college students and the data were collected using surveys. The results of data analysis using the partial least square method indicated that the use of multimedia has a positive effect on the adaptation of multimedia technology by learners.

Samat and Aziz (2020) combined CTML and dual coding theory (DCT) (Clark and Paivio, 1991) to design and study the effectiveness of multimedia learning in enhancing reading comprehension among indigenous pupils. Their collected data from 20 indigenous pupils in one primary school in Malaysia and the subsequent analysis using the judgment sampling technique indicated the usefulness of the implementation of multimedia learning in teaching reading comprehension. The researchers suggested that the combination of multiple elements of media scaffolded the understanding process while audio was the least effective one in helping pupils comprehend the information.

More recently, Pantazes (2021) explored the extent to which the 11 principles of CTML are used in the creation of instructional videos for online learning in higher education using a mixture method (i.e., combining constructivist learning theory and CTML). The results of 55 surveys and 5 interviews with online instructors revealed that CTML design principles are

implemented more often than not but some principles such as the *redundancy principle* are applied less frequently. The instructors decide on video designs and the CTML principles to use based on the audience students, their personal experiences, and preference rather than their knowledge of the design principles. Based on these observations, the authors provided some recommendations for instructional video designers to consider such as: including more signals in their videos, minimizing the use of checking on-screen texts, etc. The researchers of this study reminded us that the CTML design principles are not tools and the way they are being used matter the most.

Aravind and Rajasekaran (2021) investigated the impact of incorporating CTML into online learning for students with learning disabilities. 24 students with dysphasia in learning disabilities participated in the study and the data were collected and evaluated using pre-test, post-test, retention test, and Vocabulary Knowledge Scale [VKS] questionnaires. The multimedia instructional method of teaching used in this study outperformed the non-multimedia one in the control group. The VKS questionnaire and the retention test indicated the students with dysphasia could retain most of the vocabularies when the CTML was used as they have been stored in their long-term memory effectively.

Howze-Owens (2021) used a combination of three frameworks and theories including the CoI framework, CTML, and professional development frameworks to develop online teaching and explore the experience and response of the instructors to audio/video-based student engagement tools for multimedia teaching presence for online learning. 10 faculty and pre-faculty instructors for an online institution consisting of undergraduate and graduate students participated in this study. The results of this research showed that instructors navigate the online teaching experience via community collaboration. Participant instructors in this study reported a good response to



effective design and organization for humanized engagements with students. However, they shared their concern regarding low institutional support for integrating multimodalities.

### **Justification of the Study**

Despite the wide applications and study of the effectiveness of CTML principles in the literature, there is still a lack of studying its interaction effect with Andragogy theory. T&D design in higher education environments has particularly received less attention. Moreover, most of the studies were done in experimental settings in the industry, in which the state-of-the-art techniques are commonly used. However, studies utilized these techniques in the academia was still limited.

Equipped with experience designing top capability-building programs for a world-class university and a global social media company, the research of this study has a strong desire to learn more about how the performance and experience of adult learners could be enhanced by incorporating scientific theories and guidelines into online learning designs. Ultimately, the researcher aimed to provide practical guidelines that could possibly improve the design and implementation of instructional materials in online learning environments for adult learners.

Another aspect of this study is the use of practices that are used in the actual instructional setting for the design and implementation of the case study T&D and collection of quantitative and qualitative data from an actual classroom setting rather than experimental laboratory settings that have been used in other studies.

### **Summary**

Despite the substantial roles of applications of multimedia materials for enhancing outcomes and experiences in modern online learning, their benefit highly depends on how they have been implemented in a course or an instruction. As a widely accepted and practiced approach,

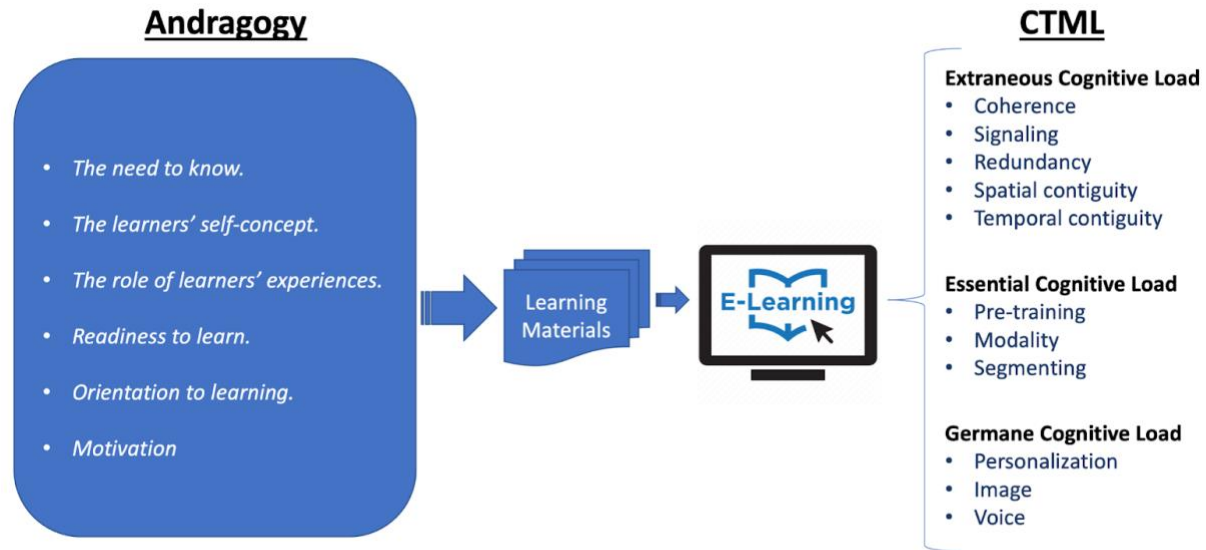
CTML, can be an effective guideline to fine-tune the learning experience for a specific learner through its combination with Andragogy.

This could help to ponder the practical aspects of multimedia instructional design and the fundamental theories of adult learning and put them into balance when creating online T&D for adult learners. Knowles (2020, p. 75) states that Andragogy does not prohibit combining it with other theories that speak to goals and purposes. Andragogy can be embedded within many different sets of goals and purposes, each of which may affect the learning process differently.

There have been no studies solely focused on the effectiveness of the combination of Andragogy and CTML in higher education. Published peer-reviewed articles that discussed the effects of an individual CTML principle or particular media did not discuss the combined effects of CTML principles and Andragogy. Thus, the proposed approach lacks substantive research backing.

The apparent lack of literature that marries these two learning theories and investigates their effectiveness in elevating adult learners' experience in online T&Ds is a gap that this study attempted to address. Furthermore, this research took on added significance when the COVID-19 pandemic of 2020 caused the entire Higher Education ecosystem in the United States to move to digital instructional models. Strategically incorporating Andragogy allowed the researcher to build sustainable and flexible technological training programs for learners in higher education. Incorporating CTML principles enables the learners to eliminate this extraneous processing and thus make the best use of the limited processing capacity to process the information relevant to the instructional goals. Thus, the researcher of this study drew on the Andragogy principles and the CTML to shape the design, development, and evolution of self-paced online learning.

### **Figure 3**



This research combined two different theoretical lenses. The first theory, Andragogy, provides a flexible and broad lens for the integration of adult learning characteristics into the process of creating instructional materials and addresses the multitude of inputs instructors incorporate into the creative process of learning content. The second theory, the Cognitive Theory of Multimedia Learning (CTML), provides a lens for analyzing the learning effectiveness of designed T&D. CTML frames the analysis of the outputs of the design process. Taken together, the two theories help illuminate the interactions and relationships between the learners and learning design. This research framework has been depicted in Figure 1, which it is demonstrated how these two will be integrated into the T&D design process. On the left side of Figure 1, components of Andragogy contribute to the creation of learning materials. CTML design principles, grouped based on cognitive load types, are the mechanism for organizing the learning materials into the final online T&D.

## **CHAPTER III**

### **METHODOLOGY**

*“All improvement requires change, but not every change is an improvement.”*

*-Eliezer Yudkowsky*

The purpose of this study was to investigate the effectiveness of the combined method of andragogy and cognitive load of multimedia learning (CTML) in (1) enhancing learning results in T & D programs in higher education; and (2) optimizing students' learning experiences regarding learning motivation, autonomy, and satisfaction.

This study was carried out in the Training & Development (T & D) program of a university on the west coast U.S. The primary purpose of the T & D in this university is to help students close the performance gap in technological skills and prepare them for the technical skills needed in the workplace.

In this chapter, the research design was detailed. Following a restatement of the research questions, participants, protection of human subjects, instrumentation, procedure, data collection, data analysis methods, and the qualifications of the researchers are provided. The limitations of the research were addressed at the end of this chapter.

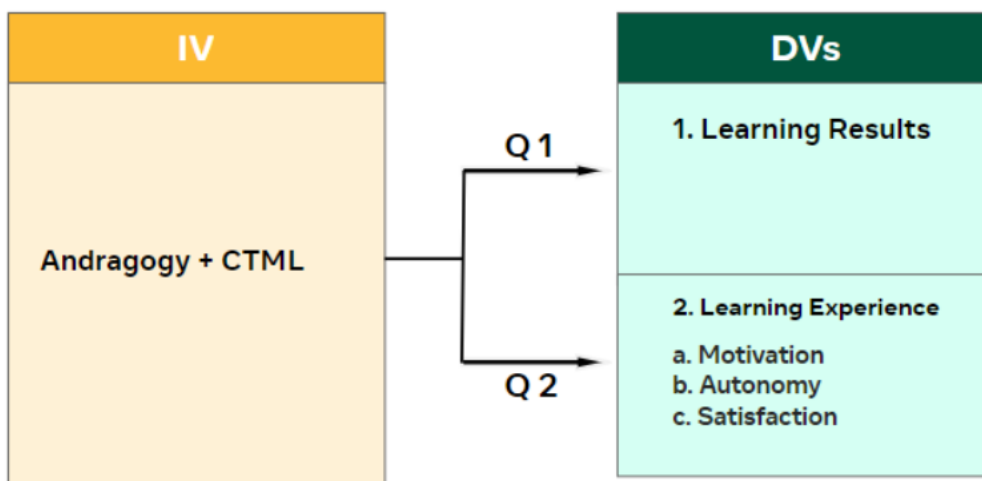
#### **Research Design**

The purpose of this study was to investigate the effectiveness of the combined method of Andragogy and cognitive load of multimedia learning (CTML) in (a) enhancing learning results in T & D programs in higher education; and (b) optimizing students' learning experience regarding learning motivation, autonomy, and satisfaction. The combined method of Andragogy and CTML was the independent variable for this study. The first dependent variable for this study is the learning outcome, which was measured by multiple-choice quizzes. The second

variable for this study was the learning experience (i.e., learning motivation, autonomy, and satisfaction), which was measured by the Likert scale of a survey.

**Figure 4**

*Research Design*



This study was conducted in a private religiously affiliated university in the west coast of U.S. Participants took the Mastering Excel Essentials for Real World training class, which is a T&D program of the university administered by the Instructional and Technology Training (ITT) department. Prior to conducting the study, the researcher observed the three training classes that was delivered through the Zoom video conferencing tool and reviewed the training documentation thoroughly.

Collaborated with the ITT staff, the researcher developed two self-paced Excel training: (1) the conventional training for the control group, which included micro video tutorials, hands-on activities, and text-based handout; and (2) Andragogy and CTML-enhanced training for the treatment group, which included micro video tutorials, simulated activities, and mind map handout. The training for both groups was designed on Storyline 360, an industry-standard eLearning authoring tool. A SCORM package, exported from Storyline 360, was uploaded into

Canvas, the learning management system that the university has been using for years. An expert panel was assembled to validate the instruments that were used to measure the learning results and learning experience. A discussion board was designed on Canvas for participants to ask questions and post concerns and feedback.

Participants voluntarily signed up for the training class offered by the ITT department of the university. They were randomly assigned to either the control group or the treatment group. A pre-quiz, composed of 15 multiple-choice questions, was conducted at the beginning of the training to evaluate students' prior knowledge. The training was segmented into three modules. The exact same multiple-choice quiz question was conducted at the end of each learning module. Participants in each group only had one attempt for each quiz question. A survey that included 15 Likert scale questions was inserted at the end of the learning experience for the researcher to better understand participants' experiences and opinions toward the training they took (i.e., conventional training and Andragogy and CTML enhanced training).

**Table 5**

*Research steps*

Preparation	Control group	Treatment group	Post Learning
Step 1: Observed the classes, review training documentation	Step 1: Conducted pre-test	Step 1: Conducted pre-test	Step 1: Analyzed data
Step 2: Designed and developed learning material	Step 2: Delivered the online learning	Step 3: Delivered the online learning	
Step 3: Developed and validated instruments	Step 3: Conducted post-test	Step 3: Conducted post-test	
Step 4: Recruited participants	Step 4: Conducted the survey	Step 4: Conducted the survey	

### **Research Questions**

The research questions that will be addressed in this dissertation are as follows:

1. To what extent was there a difference in the learning result between the participants who took the conventional instruction and the participants who took Andragogy and CTML-enhanced training as measured by the pre-and post-test scores?
  - a. To what extent was there a difference in the pre-test score between the comparison and the treatment group?
  - b. To what extent was there a difference in the post-test score between the comparison and the treatment group?
  - c. To what extent was there a difference in the gained score between the comparison and the treatment group?
2. To what extent was there a difference in the learning experience between the participants who took the conventional training and the participants who took Andragogy and CTML-enhanced training?
  - a. To what extent was there a difference in learning motivation as measured by the Likert scale of a survey?
  - b. To what extent was there a difference in learning autonomy as measured by the Likert scale of a survey?
  - c. To what extent was there a difference in learning satisfaction as measured by the Likert scale of a survey?

3. How was the learning experience different between the participants who took the conventional training and the participants who took Andragogy and CTML-enhanced training?

### **Research Setting**

The study was conducted in a private religiously affiliated university in the west coast of the U.S. The training classes will be offered by the ITT department of the university. 5,852 undergraduate and 4,216 students enrolled in this university in Fall 2020 with a total enrollment of 10,068. Among all the enrolments, White, Asian, and Latino account for the largest proportion with a population of 2,739, 2,224, and 2,114 respectively, taking account of 27%, 22%, and 21% of all the population, followed by the international population of 1,325, taking account of 13%. 800 multi-race students enrolled in the university, taking account 8% of the total population, followed by African Americans with an enrollment of 642, taking account 6% of the total. There are 163 students whose race remains unknown, taking account 2% of the total enrollment. The native Americans account for the least proportion of the total population, with an enrollment of 14, taking account 0.1% of the total population.

**Table 6**

*Diversity of Total Student Population (Fall 2020)*

Race	Population	Percentage
White	2,739	27
Asian	2,224	22
Latino	2,114	21
International	1,325	13
Multi Race	800	8



African American	642	6
Unknown	163	2
Native Hawaiian/Pacific Islander	47	0.5
Native American	14	0.1
Total	10,068	100

*Note.* The data are from the official website of the religiously affiliated university in the U.S.

Participants undertook the Mastering Excel Essentials for Real World training class. The training was conducted from October 7, 2022 to November 6, 2022. The training for both groups were administrated on Canvas and tool about 60 minutes to complete. The pre-test quizzes were conducted at the beginning of the training and the post-test quizzes were conducted at the end of each learning module. The students had only one attempt for each multiple-choice quiz question. The researcher enrolled the participants to the Canvas course three days before the training class takes place. The researcher set up auto-reminder on Canvas to remind students to keep up their great learning before the weekends.

### **Participants**

The participants in this study were the students who were enrolling in academic degree programs in the religiously affiliated university on the West coast of the U.S. Participants were from one of the five schools that are affiliated with the university: College of Arts and Sciences, School of Law, School of Management, School of Education, and School of Nursing and Health Professions. Participants who have already mastered advanced skills in Excel or aged under 18 years old will be excluded from the study. Age, gender, educational background, and ethnicity

information of the participants was collected along with the digital consent form at the beginning of the eLearning.

### **Sample Recruitment**

The students from a private religiously affiliated university in the U.S. constituted the convenient sample for this study. The T&D programs, administered by the ITT department, provided free educational technology training to facilitate faculty, staff, and students' digital literacy. In previous years, the students registered for the workshops through the student registration forms that were provided on the ITT website. There were about 60 students participated in the Excel training each semester. Due to the unprecedented pandemic of Covid-19, the registration volume has dropped to about 30 students each semester. To recruit more participants, the ITT director and the researcher took the following four actions.

First, the researcher designed an adobe spark page to advertise the training opportunity. The webpage included information such as the purpose of the study, the locations of the study, the time commitment of the participants, benefits to the participants, the timeline of the experiment, and a registration link. This page allowed the researcher to share the study with faculties in the university so that they encouraged their students to participate.

Second, the researcher distributed eight \$20 Amazon gift cards, which encouraged students' participation. Specifically, four gift cards were distributed by random drawing and the rest four gift card were given to the interviewers.

Third, the director of ITT emailed sixty students who registered for the Excel training but didn't make it. The researcher followed up with those students. Overall, the method successfully recruited 20 participants.

Fourth, the researcher emailed this training opportunity to faculty whose contact information was available on the university website. The researcher detailed the purpose of the study, the research plan, the locations the study will be conducted, the duration of the training, registration form, followed by participants' benefits, compensation, and cost. This strategy boosted the sample size to seventy.

Based on the measures taken, the researcher recruited 70 participants in this study. Given that this training was a voluntary non-credit course and that it took place in the mid-term, some students can't manage to complete it. Data of those who completed the training has been investigated and those who did not complete the training has been excluded. 44 students have fully completed the training and the demographics is shown in table 7 below.

**Table 7**

*Demographics of the Participants*

	Subgroup	Control Group	Treatment Group
Gender	Female	10	13
	Male	12	9
Ethnicity	White	5	4
	Asian	7	8
	Latino	4	3
	African American	2	3
	International	3	2
	African American	1	2
Education Level	Undergraduate	13	11
	Graduate	4	5

	Doctorate	5	6
School	School of Management	8	10
	School of Education	7	6
	School of Nursing	3	2
	School of Law	4	3
	College of Arts and Sciences	0	1

### **Protection of Human Subjects**

Approval for this study was requested from the University of San Francisco's Internal Review Board for Protection of Human Subjects. A permission letter was obtained from the director of the ITT department. Students voluntarily participated in the study without any potential harm to their mental and physical health. Given all the participants are more than 18 years old, parental consent for research participation was be obtained. A notification email was sent through Canvas to notify the timeline, compensation, and estimated time commitment of the training. The rights and confidentiality of research participants were protected. To protect participants' privacy, pseudonyms were created for all the instruments of the research. Participants' records of the quizzes and survey were accessible by the researcher exclusively and were deleted forever after the research. Informed consent was obtained from each research participant at the beginning of the training program.

### **Instrumentation**

This section focused on the different research instruments that were used to generate, collect, and analyze data. There were two quantitative instruments used in this study. The quizzes were utilized to measure students' prior knowledge and learning results in both groups. The survey was distributed at the end of the training to investigate students' learning motivation, autonomy, and satisfaction.

### **Pre-test and post-test quizzes**

Assessment of learning outcomes helps to determine the instructional effectiveness of instruction (Mayer, 2020, p. 229). Mayer claims that learning outcomes can be assessed through learners' knowledge comprehension and skill transfer (Mayer, 2020, p. 239). In this study, the multiple-choice quizzes were used to measure the dependent variables – learning results. The quiz was conducted at both the beginning and the end of the training. The quiz, provided in Appendix E, contained 15 multiple-choice question items. Each multiple-choice question item worth 6.67 points, so that each participant could receive 100 points maximum. The quizzes were graded automatically by Storyline 360, which sent the learning result to the gradebook on Canvas. The pre-training quiz took no weight in students' final score, while the exact same post-quiz weighed 100%. The quiz questions, aligned with course content, was used to measure students' knowledge such as creating worksheet, using AutoFill, performing basic formulas, managing rows and columns, inserting charts, modifying charts, etc., which was instructed in the self-paced eLearning.

### **Learning Experience Evaluation Survey**

The instrument was based on Donald Kirkpatrick's Four Levels of Learning Evaluation (Kirkpatrick, 2016). The four levels of Kirkpatrick's evaluation model are as follows:

1. Reaction - The degree to which participants find the training favorable, engaging and relevant to their study or work.

2. Learning - The degree to which participants acquire the intended knowledge, skills, attitude, confidence, and commitment based on their participation in the training

3. Behavior - The degree to which participants apply what they learned during training when they are back on study or work.

4. Results - The degree to which targeted outcomes occur as a result of the training and the support and accountability package.

The purpose of this survey was to investigate the difference of students' learning experiences regarding learning motivation, autonomy, and satisfaction. Accordingly, only the first level, *reaction*, of the Kirkpatrick's evaluation model was measured. The survey included 15 close-ended questions, which was provided Appendix F. The survey was embedded at the end of the eLearning, which was developed on Storyline 360. The participants were asked to rate the degree of their learning motivation, autonomy, and satisfaction in the 5-point Likert questions, with 1 being strongly disagreed and 5 strongly agree (i.e., 1 = strongly disagree; 2 = disagree; 3 = neither disagree nor agree; 4 = agree; 5 = strongly agree). The results were coded in the way that each point of the Likert scale worth 2 point score (i.e., strongly disagree = 2 point; disagree = 4 Points; neither disagree nor agree = 6 points; agree = 8 points; strongly agree = 10 points). The survey items from one theme were mixed parallelly with items from another theme. For example, the first survey item in the learning motivation theme was followed by the first survey item in learning autonomy theme, which was followed by the first item in the learning satisfaction theme. The survey took about 2 - 3 minutes to complete.

### **Zoom interview**

The science of assessment is also concerned with determining the characteristics of the learner. Thus, a follow-up Zoom interview was conducted to obtain a deeper understanding of participants' learning experience in the conventional training and the Andragogy and CTML-enhanced training. The individual interviews were conducted and captioned through Zoom. The researcher followed Fontana and Frey's (2005, 1994) category of interviewing and designed three interview themes: learning benefit, learning engagement, and learning iteration. The learning benefit theme allowed the researcher to gain learners' overall satisfaction with the training. The learning engagement informed the researcher with in-depth knowledge about what learning initiative worked well in helping learners to learn. The learning iteration theme generated first-hand knowledge about what can be improved in the course design. Based on the three interview themes, the researcher developed six central questions that have been used to structure the interview, which were provided in Appendix G.

### **Reliability of the instruments**

The researcher collaborated with the ITT staff to design the question items to ensure the construct validity of the instruments. To verify the validity of the instruments in this mixed-method research, the researcher assembled an expert panel to review the construct validity. The experts work as technology specialist in the university with a dedication to improving the technical competency of the university community. The expert panel evaluated the clarity of wordiness, negative wording, overlapping responses, appropriateness of item responses, use of technical language, application, and alignment with training objectives and course materials. Before launching the experiment, the researcher conducted a pilot test among four students to ensure the proper administration of the eLearning experience and the reliability of the instruments.

## **Procedures and Treatment**

The study was conducted in a private religiously affiliated university on the west coast of the U.S. The training classes was offered by the ITT department of the university. The researcher worked with the instructor to transform the course content into self-paced online learning, including design exercise activities, develop video storyboards, design videos, develop handouts, create simulations, and develop the eLearning SCORM package. Participants voluntarily signed up to undertake the Mastering Excel Essentials for Real World program through a Google Sheet form. The training class started on Oct 7, 2022 and ended on Nov 6, 2022. Participants were randomly assigned to the control group and the treatment group by the researcher.

### **Pre-training phase**

In the pre-training phase, the researcher collaborated with stakeholders to apply for IRB approval, develop the eLearning, and recruit participants. To ensure the timeline worked out, the research worked proactively and parallelly. While waiting for IRB approval, the researcher proactively designed the self-paced training to ensure the data collection would not be delayed. Specifically, the researcher observed the Excel training session and review the training documentation thoroughly. The researcher then collaborated with the course instructor to re-scope the training and designed learning initiatives, such as exercise activities, video storyboards, video tutorials, handouts, simulations, learning outcome assessments, surveys, and the eLearning SCORM package. Once the expert panel validated the course materials, treatment, and instrument, the researcher initiated the participants' recruitment with the help of the stakeholders. Upon receiving the IRB approval on Oct 2, 2022, the researcher immediately rolled out the pilot test among four participants and iterated the eLearning experiences based on the feedback that arose from the pilot test.



## **Instructional phase**

The instruction for both control and treatment groups was a self-paced asynchronous training designed on Storyline 360 and administrated on Canvas. The training took about 60 minutes for students to complete. The conventional Excel training for the control group included learning initiatives such as video tutorials, exercise files, and text-based handouts, while the Andragogy and CTML-enhanced training for the treatment group included video tutorials, simulated hands-on activities, and visual-based mind map handouts. The learning experience for both groups was designed on Storyline 360, an industry-standard eLearning authoring tool. A SCORM package, exported from Storyline 360, was uploaded into Canvas, the learning management system that the university has been using for years, for students to take the self-paced training at their convenience. A multiple-choice quiz was conducted at the beginning of the training to assess participants' prior knowledge and was embedded at the end of each learning module to assess learning results. The survey, designed to measure learning motivation, autonomy, and satisfaction, was conducted at the end of the training. Students undertook the self-paced online learning on their convenience from Oct 7, 2022 to Nov 6, 2022. The topics the instructor addressed in the training class are as follows:

- 1) Module 1: Getting Started
  - a. Creating a workbook
  - b. Modifying worksheet
  - c. Performing basic formulas
- 2) Module 2:
  - a. Formatting dates & time
  - b. Working with rows & columns

- c. Freezing panes
- 3) Module 3: Creating and modifying charts
  - a. Creating charts
  - b. Modifying charts

### **Post-training phase**

To obtain an in-depth understanding of students' learning experience, the researcher interviewed four participants (i.e., two in the control group and two in the treatment group). The researcher then captioned the interview recording, distributed Amazon gift cards, and computed data.

### **Treatment**

The purpose of this study was to investigate the effect of a combined method of andragogy and CTML in enhancing the learning outcomes and optimizing the learning experience for university students enrolled in an asynchronous Excel training. The independent variable for this study was the blended method of andragogy and CTML. Knowles (2020, p. 75) states that andragogy does not prohibit combining it with other theories that speak to goals and purposes. CTML has been demonstrated to be an effective method to teach complex concepts at a fast speed (Lucas & Abd Rahim, 2017). In light of the two prominent theoretical frameworks, the researcher designated to develop a new framework that helps educators to build scientific online T & D programs for learners in higher education.

This section describes the framework of the instructional design of treatment that was used in this study, followed by the theoretical justification of the framework.

### **Framework of the Instructional Design**

The researcher believes a training solution should work with students' schedules, engage students, develop the in-demand skill to solve real world problems, and prepare students for their future roles. For these reasons, the researcher streamlined the workflow that helps course facilitators and instructional designers to design science-grounded self-paced training. The researcher believes that training classes grounded in this framework will facilitate students' learning experiences and outcomes.

**Table 8**

*Framework of the Instructional Design*

<b>Step 1: Savvy start</b>
Step 1.1 Craft an actionable, results-oriented, and contextualized title.
Step 1.2 Describe the course clearly: Inform the learners about what they will learn.
Step 1.3 Address course goals and objectives: Explain what competency learners will obtain as a result of this learning.
Step 1.4 Inform the benefits of learning the target skills and the negative consequences of not learning them.
Step 1.5 Inform the practical relevance of the target skills to real life.
Step 1.6 Make human connections: Introduce yourself, your role at the institution and your experience in the subject matter.
<b>Step 2: Content Development</b>
Step 2.1 Segment: Organize and present information in smaller steps or chunks based on key concepts to reduce the cognitive load of working memory.
Step 2.2 Eliminate extraneous information that doesn't align with learning objectives.
Step 2.3 Introduce the names and characteristics of the main concepts before diving into the content presentation.
Step 2.4 Provided preliminary resources for the course.
Step 2.5 Present content with multimedia materials. E.g.: videos, mind maps, simulated activities, etc.
Step 2.6 Contextualize targeted skills by showing the practical use cases.

---

Step 2.7 Connect targeted skills with additional real-world applications/examples.

---

Step 2.8 Maintain conversational style rather than formal style.

---

Step 2.9 Record a friendly human voice with enthusiasm for narrations rather than using a machine voice.

---

Step 2.10 Use reflective questions to facilitate knowledge re-construction. E.g.: What is the difference between two concepts? What is your biggest takeaway from this class?

---

Step 2.11 Provide hands on-practice activity to facilitate knowledge retention.

---

### **Step 3: Content Closure**

---

Step 3.1 Recap the key concepts.

---

Step 3.2 Elicit emotion and a sense of achievement.  
Highlight knowledge competency learners developed - Align with learning goals.

---

Step 3.3 Provide instructional support/additional resources as needed.

---

Guideline 3.4 Call to action.

---

### **Step 4: Learning Experience Design**

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Step 4.1 Maintain coherence: Design a coherent format throughout the learning experience, including the coherent structure of each learning module, the coherent design style of the videos, mind maps, and simulations.

---

Step 4.2 Maintain spatial contiguity: Present related words and pictures spatially close to one another; Synchronize words or narration with graphics.

---

Step 4.3 Maintain temporal contiguity: Present corresponding narration and images/animations simultaneously.

---

Step 4.4 Add visual and audio cues that guide learners' attention to the relevant elements of the material.

---

Step 4.5 De-redundancy: Remove any irrelevant information from multimedia. E.g.: animation, extra frame of a screencast video, music, etc.

---

Following the framework above, the researcher collaborated with ITT staff to design the online learning experiment. The guidelines of step 1, step 2, and step 3 streamlined the development process of the course content and learning initiatives. The guidelines of step 4

streamlined the process of transforming the course content into an engaging, interactive, and effective self-paced learning experience.

### **Justification for the Study**

The framework used in this study was grounded in Andragogy. Specifically, Andragogy principles (i.e., *the need to know* principle, the *learners' self-concept* principle, the *readiness to learn*, and the *motivation* principle) guided the savvy start of the framework. Adult learners need to know why they need to learn something before undertaking the learning (Knowles et al., 2020, p. 44). Therefore, one of the first tasks of the facilitator of this study is to inform the adult of the benefits of learning something and the negative consequences of not learning it. The facilitator elaborated on the competence, skills, and knowledge that learners will obtain and how the learning would the skill benefit them. Further, the clear learning objectives were listed to allow learners to self-discover their own gaps between where they were now and where they wanted to be so that they made their own learning decisions of undertaking the learning. This was aligned with the *learners' self-concept* principle and the *readiness to learn* principle of andragogy. The procedures in the savvy start of the framework were designed to activate learners' internal motivation to learn new skills, knowledge, and concepts that are practically relevant to their life.

*The role of learners' experiences* and the *orientation to learning* principle of andragogy constituted the main guidelines of step 2 - content development and step 3 - content closure of the framework. According to the framework, the facilitators tap into the experience of learners and highlight the applicability of their experience. This allows new information to be processed through the lens of learners' life experiences, which is the philosophy of the *role of learners' experiences* principle. Furthermore, instead of dividing learning into subjects, the framework encourages course facilitators to contextualize learning curricula into real-world situation and

form a task - based learning curriculum. These practices are aligned with *the role of learners' experiences* and the *orientation to learning* principle of andragogy.

CTML constituted another basis of the framework of the treatment design, especially for the guidelines of step 2 - content development, step 3 - content closure, and step 4 - learning experience design. In this study, knowledge information was transformed into multimedia - based learning content such as video tutorials, simulations, and mind maps, which enabled learners to process information effectively with limited cognitive capacity. The course content was delivered in user-paced segments rather than as a continuous unit, which is grounded in the segmenting principle of the CTML. This online learning only introduced targeted skills that are practically relevant to the learners' life and study so that skills with a low practical relevance was excluded to reduce the cognitive load. In light of the signaling principle, visual and audio signals was added into the video tutorials, simulations, and the eLearning experience for the treatment group.

### **Data collection**

The study was conducted in a private religiously affiliated university in the west coast of the U. S. The training classes was offered by the ITT department of the university. Learners voluntarily participated in the Mastering Excel for Real World program. The training class started on Oct 7, 2022 and ends on Nov 6, 2022. This section detailed the quantitative data collection and qualitative data collection respectively.

#### **Quantitative Data Collection**

The data on the learning outcomes in both groups were collected through the quantitative methods of multiple-choice quizzes. The data on students' learning experiences were collected

from a survey. The training class started on Oct 7, 2022 and ends on Nov 6, 2022 and thus the quantitative data (i.e., multiple-choice quizzes, survey) was collected during that time.

### **Pre-test and post-test quiz**

In this study, the multiple-choice quiz was used to measure the dependent variable - learning outcomes. The pre-test quiz was conducted at the beginning and the same quiz was conducted again at the end of each learning module as a post-test quiz. The quiz is provided in Appendix E. The quiz contained 15 multiple-choice question items. Each multiple-choice question item is worth 6.67 points and students would be able to receive 100 points maximum for the training. To avoid errors caused by humans, the quiz was graded automatically by Storyline 360 and the final score was reported to the gradebook in Canvas. The pre-test quiz took no weight in students' final scores, while the identical post-quiz weighed 100%.

### **Learning experience evaluation survey**

The learning experience evaluation survey was conducted at the end of the learning experience. The survey included 15 close-ended questions as described in Appendix F. The participants were asked to rate the degree of their learning motivation, autonomy, and satisfaction in the Likert scale question items (i.e., 1 = strongly disagree; 2 = disagree; 3 = neither disagree nor agree; 4 = agree; 5 = strongly agree). The results were coded in the way that each point of the Likert scale worth 2 points (i.e., strongly disagree = 2 points; disagree = 4 Points; neither disagree nor agree = 6 points; agree = 8 points; strongly agree = 10 points). The survey took about 2 - 3 minutes to complete.

### ***Qualitative data collection***

The semi-structured interview was used as a qualitative method to obtain an in-depth perspective of students' learning in the conventional training and the Andragogy and CTML-

enhanced training. The qualitative data was collected based on the participants' earliest availability before Nov 6, 2022.

The individual interviews were conducted and captioned through Zoom. The researcher designed three interview themes: learning benefit, learning engagement, and learning iteration. The learning benefit theme allowed the researcher to gain learners' overall satisfaction with the training. The learning engagement informed the researcher with in-depth knowledge about what learning initiative worked well in helping learners to learn. The learning iteration theme generated first-hand knowledge about what can be improved in the course design. Based on the three interview themes, the researcher developed six central questions that have been used to structure the interview, which were provided in Appendix G.

The researcher followed Fontana and Frey's (2005, 1994) category of interviewing. When the meeting started, the researcher notified the participants that the meeting would be recorded and transcribed for the research purpose. The researcher also guided the participants to stop the video and change their profile name to a preferred pseudonym when the participants prefer to do so. A pseudonym was used in the transcript to protect participants' identities and privacy. The recording was only accessible to the researcher and was deleted forever after the research.

### **Data Analysis**

The quantitative data analyses were performed to determine whether there was a statistically significant mean difference in the learning result and learning experience between participants who took the conventional training and those who took the andragogy and CTML enhanced training. Both statistical and practical significance of experiment results were computed by employing a one-tail two-sample t-test (also called independent or unpaired t-test) - to examine



if there is a statistically significant difference. Cohen's d-test (Cohen, 1988) was utilized to measure the magnitude of the difference between the two groups. To ensure that all requirements of each test were met, various analyses were performed on the data prior to the test and interpretations of the results. Pandas, Scipy, Research, Matplotlib, and Seaborn software packages in Python were used for data analysis in this study. Means, standard deviations, *t-test* results, p values, and Cohen's D were presented in chapter four of this study.

This qualitative data (i.e., the semi-structured individual interview), centered on six central questions, was coded into three themes: learning benefit, learning engagement, and learning iteration. The learning benefit theme allowed the researcher to gain learners' overall satisfaction with the training. The learning engagement informed the researcher with in-depth knowledge about what learning initiative worked well in helping learners to learn. The learning iteration theme generated first-hand knowledge about what can be improved in the course design. These three themes allowed the researcher to obtain a deeper insight into how the learning experience is different between the conventional instruction and enhanced instruction based on a combined method of Andragogy and CTML.

### **Qualification of the Researcher**

The researcher has been designing top capability-building programs for a world-class university and a global-based social media company. The researcher's interest in conducting this study was driven by her professional experiences, during which the researcher gained priceless experience in designing effective learning solutions that drove organizational goals and improved employees' performance. The researcher's research ideas kept evolving as she gained more experience designing T&D programs, such as bootcamps, training series, campaigns, etc.

Having work experience in both academia and industry settings, the researcher noticed that the grounded theories of designing T&D are very different in these two settings. The T&D in the industry is result-oriented, which is designated to close learners' performance gaps. Andragogy has been the dominant designing philosophy in the T&D in the industry, as it facilitates (a) active participation of the learners; (b) real world problem-solving skills. While the T&D in academia is more subject matter-oriented, which is designated to deliver the content systematically in a scientific way. CTML is an evidence-based theory that facilitates effective processing when material is particularly complex, or the material is presented at a fast pace. Thus, CTML has gained global popularity in the T & D of the academic setting.

Knowles (2020, p. 75) states that andragogy does not prohibit combining it with other theories that speak to goals and purposes. Thus, the researcher believes combining these two dominant frameworks will allow educators to take advantage of the merits of both. The researcher believes a training solution should work with students' schedules, engage students, develop the in-demand skill to solve real-world problems and prepare students for their future roles. For these reasons, the researcher is determined to develop an effective framework that helps educators to build scientific online T & D programs for learners in higher education.

While serving as a professional, the researcher is also pursuing her Doctor of Education degree in Learning and Instruction. Her research area includes neuroscience in learning, Andragogy, Cognitive Theory of Multimedia Learning, Motivational Design, Situated Learning, Gamified Learning, etc. She shared her expertise in Learning & Instruction at multiple conferences such as the California Association of Teachers of English (CATESOL) 50th Annual Conference and Comparative and International Education Society (CIES) 2020 Miami Education Beyond the Human 64th Annual Conference. Her recent research of incorporating universal

design for learning principles into self-paced eLearning has been accepted by the renowned CIES 67th annual meeting and she will be sharing her research to international scholars in Feb 2023.

Given the researchers' academic background and professional experience, the researcher is equipped with the expertise to conduct this research.

## **CHAPTER IV**

### **RESULTS**

*“The world cannot be understood without numbers. But the world cannot be understood with numbers alone.”*

*-Hans Rosling*

#### **Introduction**

The purpose of this study was to investigate the effectiveness of the combined method of andragogy and cognitive load of multimedia learning (CTML) in (1) enhancing learning results in the Training & Development (T & D) programs in higher education; and (2) optimizing students' learning experience with regard to learning motivation, autonomy, and satisfaction. This study was carried out in the T & D program of a private religiously affiliated university on the west coast U.S. The primary purpose of the T & D in this university was to help students close the performance gap in technological skills and prepare them for the technical skills needed in their future workplace. This study discusses the incorporation of Andragogy principles and CTML into the online learning design with the purpose of leveraging their learning result and learning experiences.

This study utilized a mixed-method design of quantitative and qualitative methods. The quantitative data were collected through two instruments in both control (n=22) and the treatment

group (n=22). The first quantitative instrument was a quiz, which was administrated to measure students' learning results. The second quantitative instrument is a survey, which was distributed to investigate students' learning motivation, autonomy, and satisfaction. Qualitative data (n=4) were collected through semi-structured individual interviews from both control and treatment groups to obtain an-in depth perspective of students' learning experience. This chapter provides quantitative data analyses and reports the findings of the qualitative data regarding research questions.

### **Quantitative Findings**

The quantitative data analyses were performed to determine whether there was a statistically significant mean difference in the learning result and learning experience between participants who took the conventional training and those who took the andragogy and CTML enhanced training. Both statistical and practical significance of experiment results were computed by employing a one-tail two-sample t-test (also called independent or unpaired t-test) - to examine if there is a statistically significant difference - and Cohen's d-test (Cohen, 1988) - to measure the magnitude of the difference - among participating groups. To ensure that all requirements of each test were met, various analyses were performed on the data prior to the test and interpretations of the results. Pandas, Scipy, Research, Matplotlib, and Seaborne software packages in Python were used for data analysis in this study. To interpret Cohen's D result, the researcher refers to the effect sizes as small or no effect (i.e., d values of equal or less than 0.20), medium effect (i.e., d = 0.50), and large effect (i.e., d values of equal or greater than 0.80) following Lee (2022). Detailed analysis of the research questions is presented in separate subsections as follows.

#### **Research Question #1**

To what extent was there a difference in the learning experience between the participants

who took the conventional training and the participants who took Andragogy and CTML-enhanced training as measured by the pre-and post-test scores?

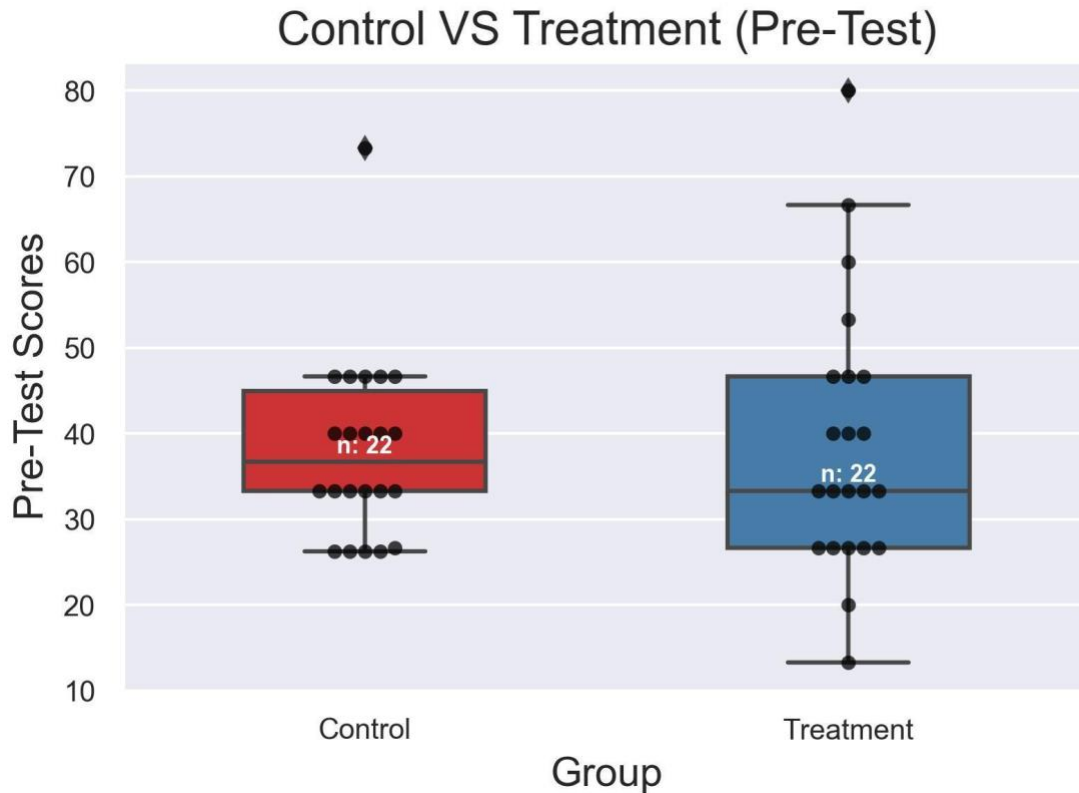
- a. To what extent was there a difference in the pre-test score between the comparison and the treatment group?
- b. To what extent was there a difference in the post-test score between the comparison and the treatment group?
- c. To what extent was there a difference in the gained score between the comparison and the treatment group?

The first research question addressed here is to investigate if there was any significant difference in the prior knowledge, learning result, and gained score between the control and the treatment groups. Three two-sample t-tests were conducted on an experimental sample of 44 participants to determine the mean differences. There were 22 participants in the control group, to whom a conventional instruction was delivered, and 22 in the treatment group, to whom an andragogical and multimedia-enhanced instruction was delivered.

**To what extent was there a difference in the pre-test score between the comparison and the treatment?** The summary of pre-test data and its distribution is presented in Table 9 and Figure 5, respectively. The boxplots demonstrate that the median of the pre-test scores for the control group is slightly higher than the mean for the treatment group. This is while the pre-test scores for the treatment group are more spread (i.e. have a higher variance) than the control group. These are in agreement with the statistical summary in Table 9 in which the treatment group exhibits a slightly higher mean, standard deviation, and standard error compared with the control group.

### **Figure 5**

*Boxplots of Pre-test Results for Students in the Control Group and the Treatment Group*



Before performing the t-test and measuring the significance of the statistical difference, one first needs to check whether the following assumptions are met for the data:

- (1) The samples in each group are independent (i.e., there is no relationship between the participants of the two groups).
  - (a) Participants in the treatment group cannot also be in the control group.
  - (b) No participant in either group can influence participants in the other group.
  - (c) No group can influence the other group.
- (2) The data have been sampled randomly from the population.
- (3) No outliers exist in the data.
- (4) The data in each group follow (approximately) a normal distribution.
  - Based on the Central Limit Theorem (Montgomery, Douglas, and Runger et al., 2014), if the sample size is large enough (the general rule of thumb is  $n \geq 30$ ) then

normality may not be a concern even if the test for normality indicates that normality is not present.

- However, if there is a strong indication of non-normal distribution, i.e., clear thick-tailed, or heavily skewed populations, one might consider transforming the data and/or using a non-parametric statistical test.

(5) The variances of data are approximately equal across groups (i.e., homogeneity of variances).

- When this assumption is violated, and the sample sizes for each group differ, the p-value is not trustworthy.
- The Welch t Test may be used when equal variances among populations cannot be assumed. The Welch t Test is also known as an Unequal Variance t-Test or Separate Variances t-Test.

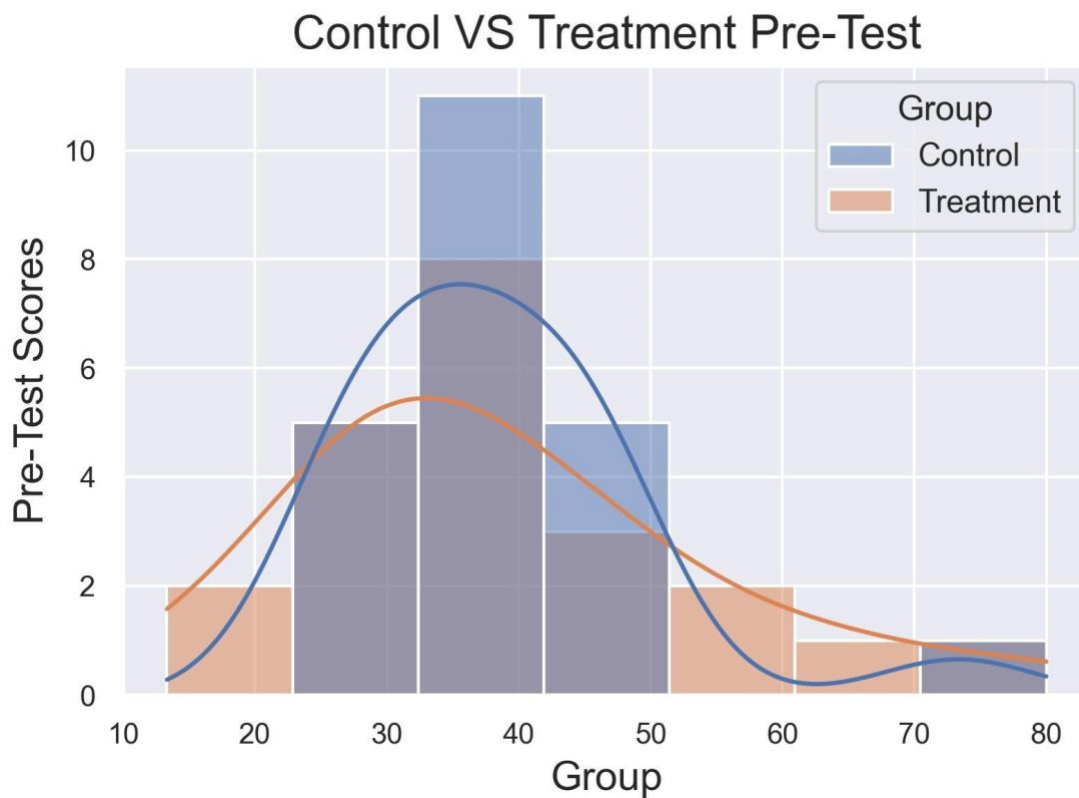
The first two assumptions (i.e., the randomness and independence of data in each group) have been considered and checked during the experiment design and setup of the study, and the researcher made sure that each individual has been randomly assigned to either control or treatment group and belongs to only 1 group. The boxplot in Figure 5 shows the existence of one outlier in each group (i.e., treatment and control). However, the researcher decided to keep them as our investigations suggest that those are natural outliers and not caused by errors in the measurement or reporting.

The fourth assumption states that the data should be (approximately) normally distributed. As in this case, the Central Limit Theorem does not apply (the sampling size of each group is less than 30). Thus, the researcher evaluated the normality of the population distributions in each group. This can be done either visually or using a formal test. The bar plot and smoothed curves presented

in Figure 6 indicate that the distribution of data in both control and treatment groups follows a nearly normal distribution. Hence, this assumption is also met for the pre-test data.

**Figure 6**

*Histogram Plots Overlaid by Smoothed Curves Demonstrating the Distribution of Pre-test Results for Students in the Control Group and Treatment Group*



The last assumption, i.e., the homogeneity of variances, is checked through some statistical methods. A common method to check this is Levene's test for equality of variances. Levene's test tests whether the different groups have equal variances (Levene, 1960). It is less sensitive than other tests to depart from normality and power (Conover, 1981). Levene's test of homogeneity of variances can test for equality between 2 or more groups. The original suggestion was to use the mean. Brown and Forsythe (1974) expanded the research and asserted that the test can also be



calculated using the median or the trimmed mean, which have been found to be robust under non-normality.

Levene's test is therefore used to test the null hypothesis that the samples to be compared come from a population with the same variance. In this case, possible variance differences occur only by chance since there are small differences in each sampling.

H0: Groups have equal variances

H1: Groups have different variances

It is important to note that the mean values of the individual groups have no influence on the result that they may differ. An advantage of Levene's test is that it is very stable against violations of the normal distribution. Furthermore, the variance equality can also be checked graphically. This is usually done with a grouped box plot, as presented in Figure 4.

Here, the researcher performed Levene's test on the mean. The result (Levene's  $F = 1.45$ ,  $p = 0.23 > 0.05$ ) indicates that the variances are not significantly different from each other (i.e., the homogeneity assumption of the variance is met). Table 9 and table 10 below present the mean, standard deviation, standard error, 95% of confidence, interval, mean difference, T-test score, p-value, and Cohen's d (effect size) for the pre-test result between the two groups.

**Table 9**

*The summary of pre-test data for the Control and Treatment Group*

Variable	Number	Mean	SD	SE	95% Conf.	Interval
Control	22	38.11	10.81	2.3	33.32	42.90
Treatment	22	38.79	15.76	3.36	31.81	45.78
Combined	44	38.45	13.36	2.01	34.39	42.52

**Table 10**

*Independent T-test Results, and Effect Sizes for Comparing Pre-test Scores Between the Control group and the Treatment Group*

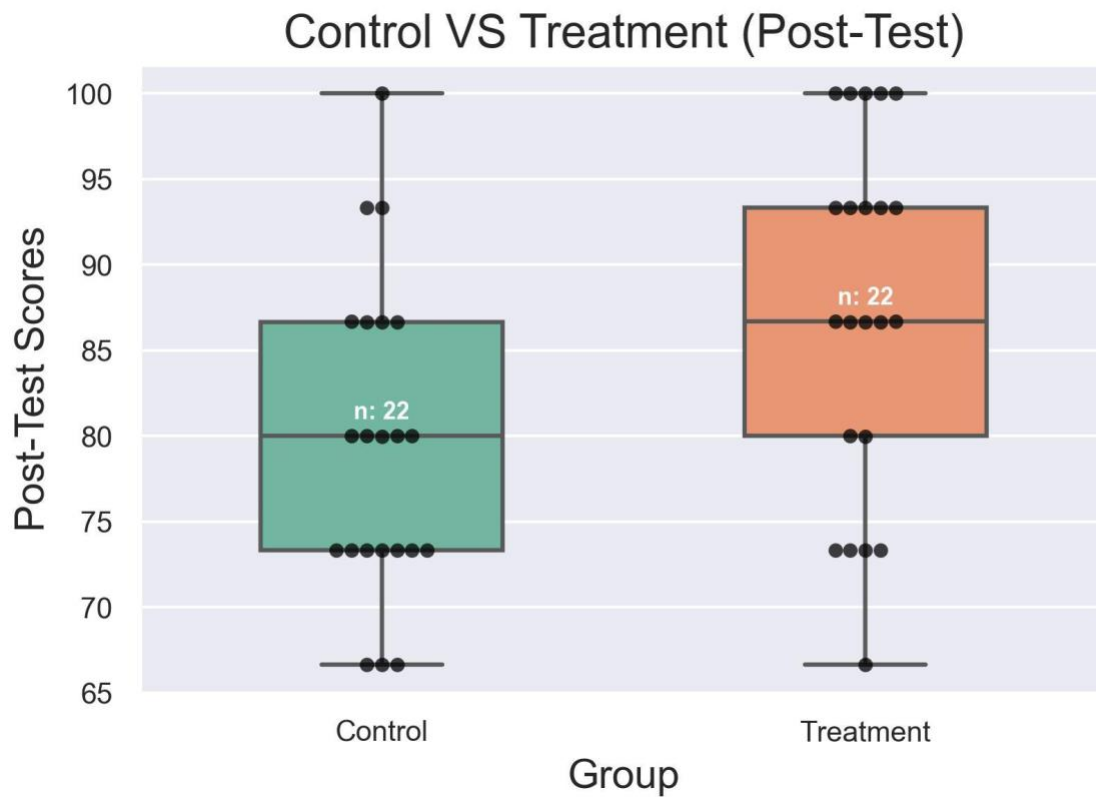
Mean Difference (Control - Treatment)	t-score df=42	p-value	Cohen's d (effect size)
0.68	0.17	0.87	0.05

Although the treatment group (Mean =38.79, SD = 15.76) began the study with a slightly higher prior knowledge than the control group (Mean =38.11, SD =10.81) as measured by the pretest scores (Table 9), the difference between the two groups had a very small effect size ( $d = 0.05$ ) and was not significant ( $t= 0.17$ ,  $p=0.87 > 0.05$ ) (Table 10). The result indicates that there is no difference in prior knowledge between the participants who took conventional instruction and those who took the andragogy and CTML-enhanced instruction.

**To what extent was there a difference in the post-test score between the comparison and the treatment group?** The boxplots and summary for the post-test data are presented in Figure 7 and Table 11, respectively. As the plots and table indicate, there is a noticeable improvement after the training intervention for the treatment group (Figure 7). The post-test data shows a more similar standard deviation (i.e., 10.47 for the treatment group vs 9.18 for the control group) between two groups (Table 11).

**Figure 7**

*Boxplots of Post-test Results for Students in the Control and Treatment Group*



**Table 11**

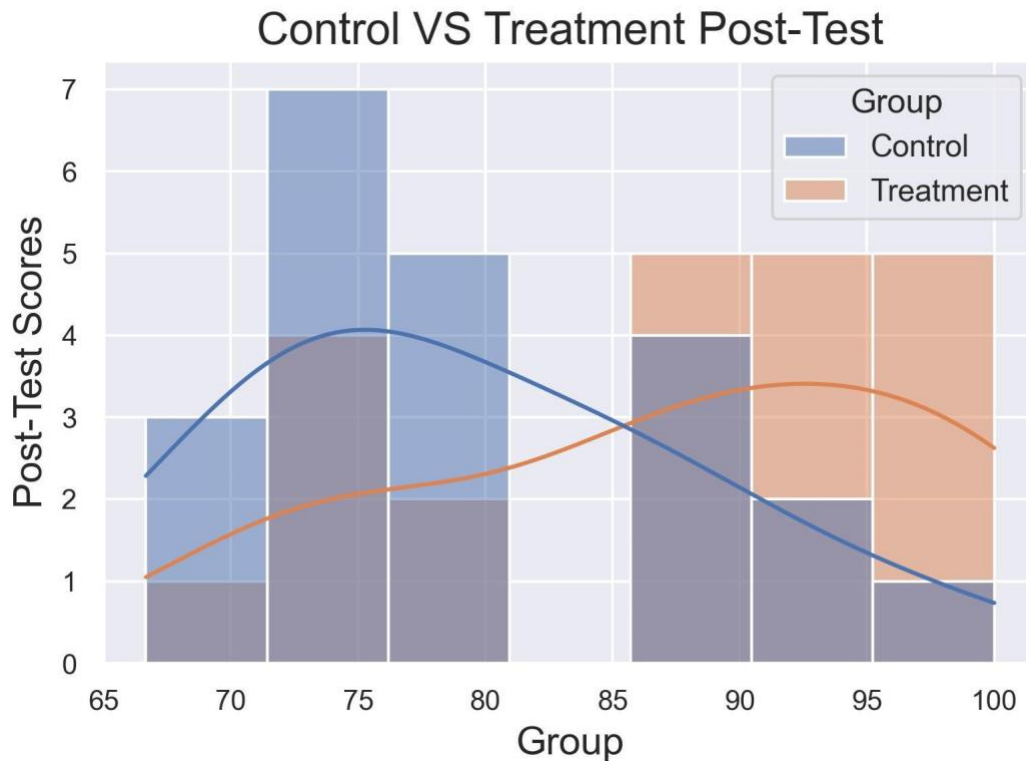
*The summary of post-test data for the treatment and control groups.*

Variable	Number	Mean	SD	SE	95% Conf.	Interval
Treatment	22	87.27	10.47	2.23	82.63	91.92
Control	22	79.39	9.18	1.96	75.32	83.46
Combined	44	83.33	10.51	1.59	80.14	86.53

Before conducting the t-test and Cohen's test to quantify the magnitude and significance of this difference, the researcher first examined whether the data met the requirements. The first three requirements (i.e., independence, randomness, and no outlier) have already been met. However, as the post-data has a more complicated distribution (Figure 8) than the pre-test data and it is difficult to assess the normality of its distributions visually, the researcher performed some additional quantitative tests.

**Figure 8**

*Histogram Plots Overlaid by Smoothed Curves Demonstrating the Distribution of Post-test Results for Students in the Control and Treatment Group*



Because of the small sample size, determining the distribution of the samples in control and treatment groups was important for choosing an appropriate statistical method. There are a few formal tests that can be used to check the normality of data. Here the researcher uses Shapiro-Wilk (SW) and Kolmogorov-Smirnov (KS) tests. The Shapiro-Wilk test is an omnibus test (D'Agostino, 1971). It evaluates normality by comparing the data's distribution (values ordered) to the hypothesized normal distribution (Shapiro & Wilk, 1965). The null hypothesis ( $H_0$ ) states that the variable is normally distributed, and the alternative hypothesis ( $H_1$ ) states that the variable is not normally distributed. So, after running this test:

- (1) If  $p \leq 0.05$ : then the null hypothesis can be rejected (i.e., the variable is not normally distributed).
- (2) If  $p > 0.05$ : then the null hypothesis cannot be rejected (i.e., the variable may be normally distributed).

The researcher performed a Shapiro-Wilk test using the SciPy package and the result (statistic=0.92, p value=0.06) suggests that the distribution of the post-test data could be considered a normal distribution. To cross-check this finding, the researcher performed an additional test using the Kolmogorov-Smirnov (KS) method. The Kolmogorov-Smirnov test is a distance test (D'Agostino, 1971). It evaluates normality by comparing the data's empirical distribution function to the expected cumulative distribution function of the comparison distribution (Öztuna D., Elhan A., & Tüccar, 2006). Similarly, the null hypothesis in this method is that the data is normal (matches compared distribution). A similar result (statistic=0.36, p value=0.11) was obtained using the Shapiro-Wilk approach suggesting the normality of post-quiz score.

Then, the researcher checked the homogeneity of variances for the post-test data among two groups using Levene's Test. The results based on the mean (statistic=0.51, p value=0.48) indicate that the post-test data for the two groups have similar variances. This is also observable from the boxplots in Figure 8. Based on these outcomes, and after a visual examination of the data for each group, the researcher concluded that the post-test data met all the requirements and decided to use the t-test as a parametric test. Also, the mean with the standard deviation was used to summarize the results (Table 12).

**Table 12**

*Independent T-test Results, and Effect Sizes for Comparing Post-test Scores Between the Control and the Treatment*

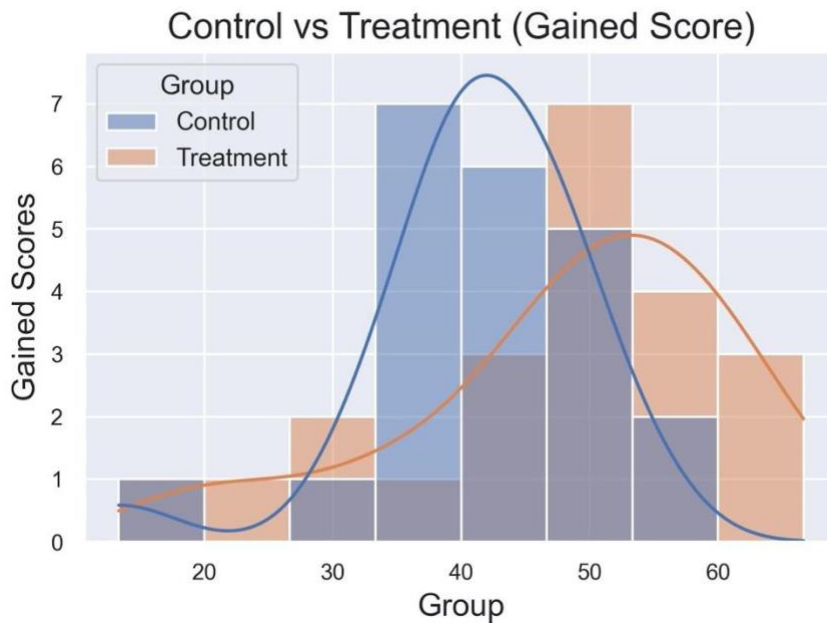
Mean Difference (Control - Treatment)	t-score df=42	p-value	Cohen's d (effect size)
7.88	2.65	0.01	0.80

The t-test result:  $t(42) = 2.65$   $p\text{-value} = 0.01 < 0.05$ , indicates a significant mean difference in post-test data between the two groups and the effect size is large ( $d = 0.8$ ). The result indicates that students who took the andragogy and CTML-enhanced instruction significantly outperformed students who took conventional instruction in the post-test.

**To what extent was there a difference in the gained score between the comparison and the treatment group?** The histogram plot in figure 9 below indicates a normal distribution of the gained score for both the control and the treatment group. The result of the Shapiro-Wilk test (statistic=0.93,  $p\text{ value}=0.15$ ) also suggests that the distribution of the gained score could be considered a normal distribution. The result of the Levene's test (statistic=2.05,  $p\text{ value}=0.16$ ) indicates that the gained score for the two groups has similar variances.

**Figure 9**

*Histogram Plots Overlaid by Smoothed Curves Demonstrating the Distribution of Gained Scores for Students in the Control Group and Treatment Group*



**Table 13**

*The summary of Gained Score for the Control and the Treatment group*

Gained Score	Number	Mean	SD	SE	95% Conf.	Interval
Control	22	41.28	8.43	1.80	37.55	45.02
Treatment	22	48.48	12.55	2.67	42.91	54.04
Combined	44	44.88	11.17	1.68	41.48	48.28

**Table 14**

*Independent T-test Results, and Effect Sizes for Comparing Gained Scores Between the Control and the Treatment*

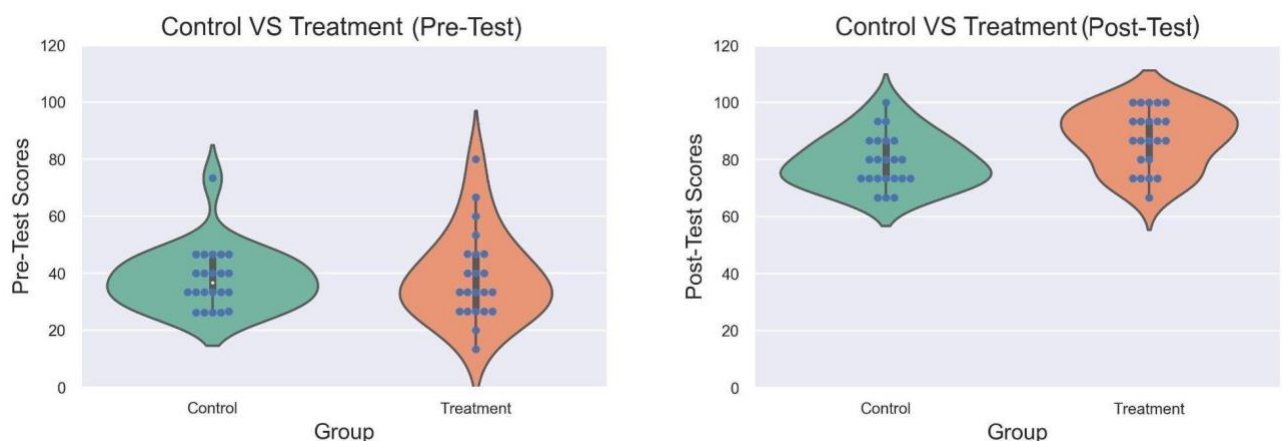
Mean Difference (Control - Treatment)	t-score df=42	p-value	Cohen's d (effect size)
7.19	2.23	0.3	0.67

Even though participants from the treatment group started with a lower prior knowledge (yet not statistically significant), they gained more score ( $M = 48.48$ ,  $SD = 12.55$ ) than their control

group counterparts ( $M = 41.28$ ,  $SD = 8.43$ ). The t-test result:  $t(42) = 2.23$   $p\text{-value} = 0.3 < 0.05$ , indicates a significant mean difference in the gained score between the two groups and the effect size is medium ( $d = 0.67$ ). The result suggests the effectiveness of the andragogical and CTML-enhanced instruction in maximizing students' learning result. This is clearly observable from the violin plots in Figure 10 below. The data for both groups have a one-side and upward tail, which indicates that both the conventional instruction and the andragogical and CTML-enhanced instruction were effective in improving learning results. Additionally, the tail of the post-test data for the treatment group is higher than the tail of the post-test data for the control group, which suggests that the andragogical and CTML-enhanced instruction was more effective in facilitating learning results. The tail of the post-test data for the treatment group exhibits a downward pattern and the majority of learners have gained higher scores (the widest part of the violin shape) as compared to the control group in which the tail is upward and fewer students were able to obtain the full score.

**Figure 10**

*Violin Plots of the Pre-test (left) and Post-test (right) for Students in the Control and the Treatment Group*

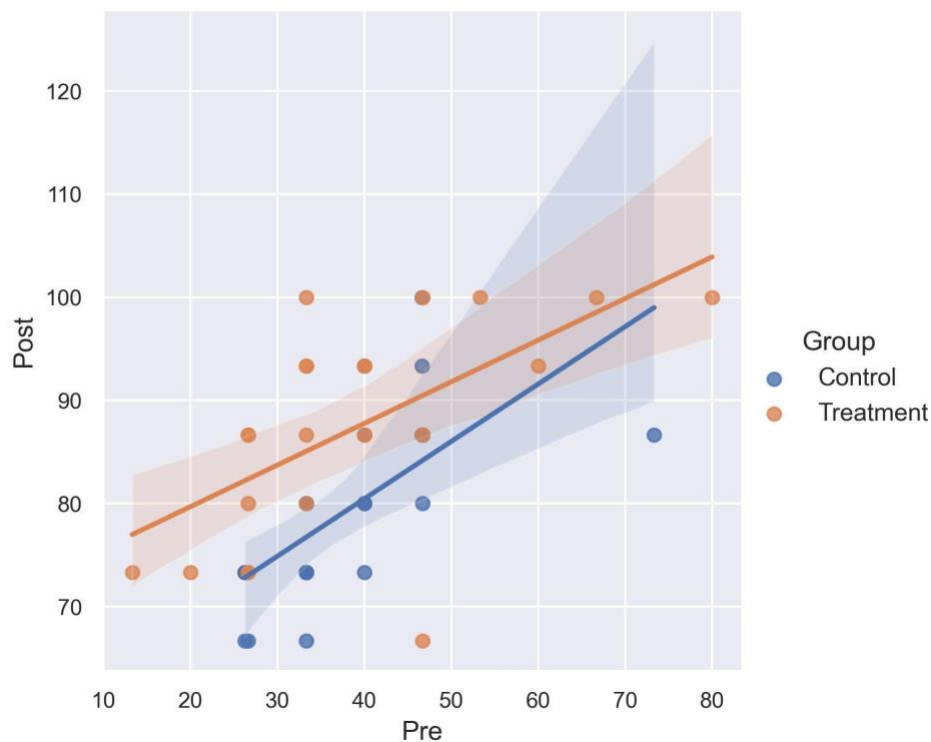




A similar pattern can be seen from Figure 11. In this plot, each dot represents the pre-test result or post-test result for an individual student in the treatment (orange) and control (blue) groups. The solid lines depict the fit to the points in each group, and the shadow represents the confidence interval. A density of points between 25 to 50 pre-scores indicates that the majority of students (in both groups) have a less than average (i.e.,  $< 50\%$ ) prior knowledge of Excel. The density of points between 73 to 100 in this figure indicates that the training helped learners in both groups to improve their knowledge. The orange points of the post-test score were populated between 73 to 100 and the blue points of the post-test score were populated between 65 to 95, which indicates the knowledge improvement was more effective for the treatment group.

**Figure 11**

*Regression plot of the Pre-test (horizontal axis) and Post-test (vertical axis) for Students in the Control and the Treatment Group*



In summary, there exists a significant difference between the learning results of the control and the treatment group as measured by the differences between pre-test and post-test scores. Table 14 below presents the summary of the results regarding the difference in prior knowledge, learning results, and the gained score between the comparison and the treatment group. The independent T-test result of the pre-test data ( $t(42) = 0.17, p=0.87 > 0.05$ ) indicates that there is no difference in prior knowledge between the participants who took conventional instruction and those who took the andragogy and CTML-enhanced instruction. Although both methods used by the control group and the treatment group were effective in increasing the learner's learning of Excel, there is a distinct difference between the distribution of learning results in the post-test data. The independent T-test result of post-test scores ( $t(42) = 2.65$  p-value =  $0.01 < 0.05$ ) indicates a significant mean difference in post-test score between the two groups and the effect size is large ( $d=0.8$ ). In terms of the gained score between two groups, the t-test result of the gained score ( $t$

(42) = 2.23 p-value = 0.3 < 0.05) indicates a significant mean difference in the gained score between the two groups and the effect size is medium ( $d = 0.67$ ). Thus, this study suggested the andragogical and CTML-enhanced instruction is very effective in improving students' learning in the self-paced technological program.

**Table 15**

*Descriptive Statistics, Independent T-test Results, and Effect Sizes for Comparing Prior Knowledge, Learning Results, and the Gained Score*

Variable	Control Group (N=22)		Treatment Group (n=22)		T-test (df=42)	P- value	Cohen's D
	Mean	SD	Mean	SD			
Pre-test	38.11	10.81	38.79	31.81	0.17	0.87	0.05
Post-test	79.38	9.18	87.27	10.47	2.65	0.01	0.80
Gained Score	41.28	8.43	48.48	12.55	2.23	0.3	0.67

## Research question #2

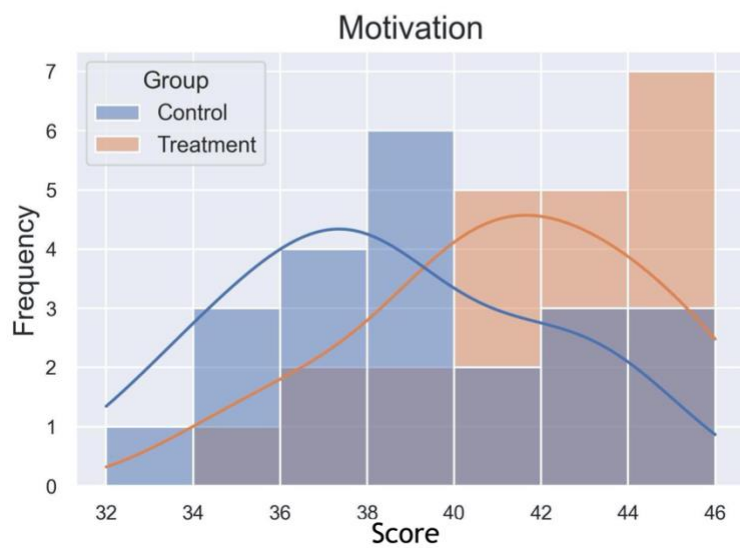
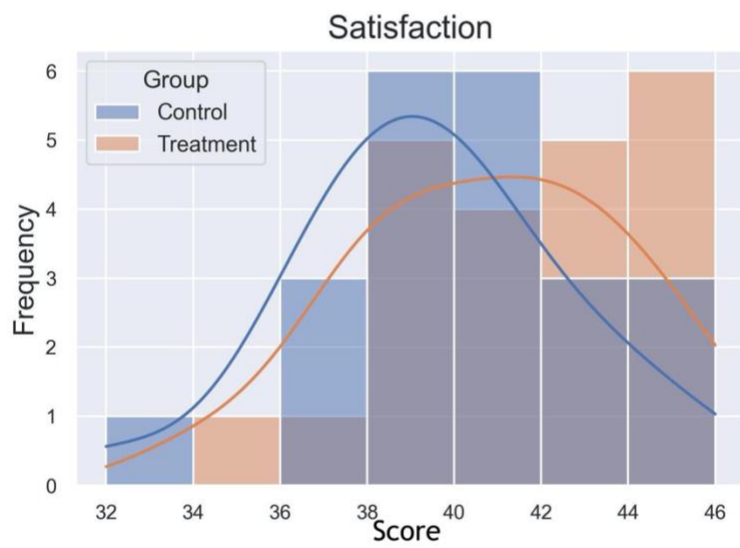
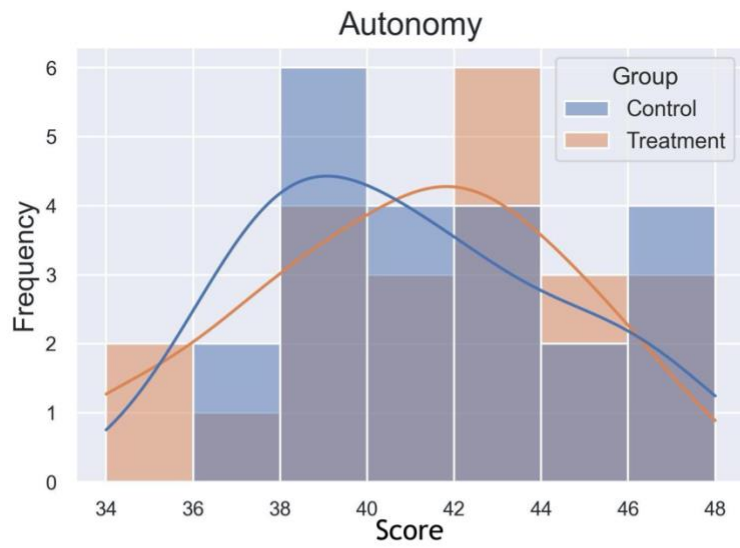
To what extent was there a difference in the learning experience between the comparison and the treatment group?

- To what extent was there a difference in learning motivation as measured by the Likert scale of a survey?
- To what extent was there a difference in learning autonomy as measured by the Likert scale of a survey?
- To what extent was there a difference in learning satisfaction as measured by the Likert scale of a survey?

This research question was to investigate the difference in students' learning experiences regarding learning motivation, autonomy, and satisfaction. The survey included 15 close-ended questions, which are provided by Appendix G. The participants were asked to rate the degree of their learning motivation, autonomy, and satisfaction in the 5-point Likert questions, with 1 being strongly disagreed and 5 strongly agree (i.e., 1 = strongly disagree; 2 = disagree; 3 = neither disagree nor agree; 4 = agree; 5 = strongly agree). The results were coded in the way that each point of the Likert scale worth 2 points (i.e., strongly disagree = 2 points; disagree = 4 Points; neither disagree nor agree = 6 points; agree = 8 points; strongly agree = 10 points). Distributions of survey data for the three aspects of the learning experience are presented in Figure 12 below.

**Figure 12**

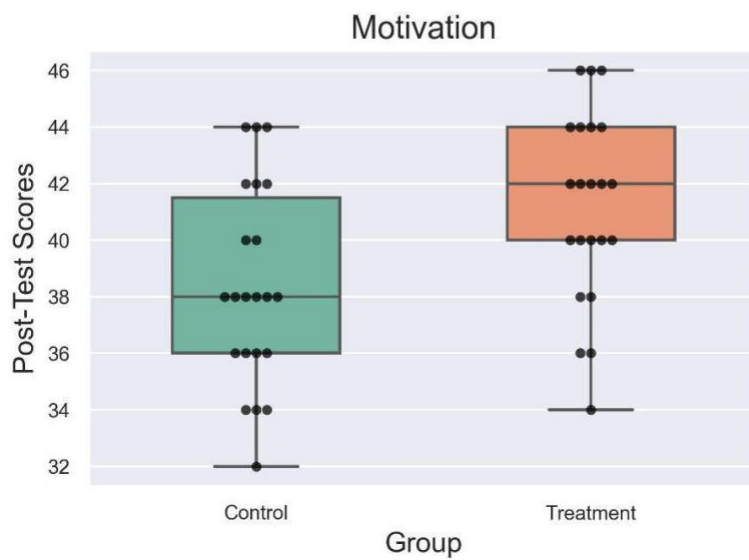
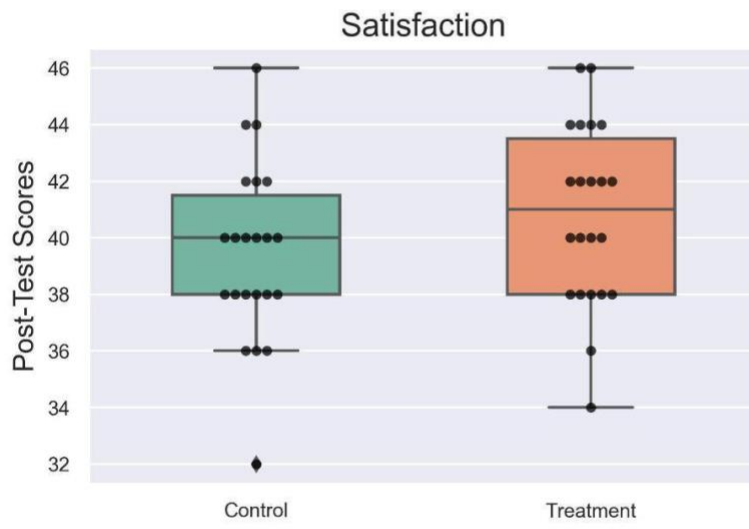
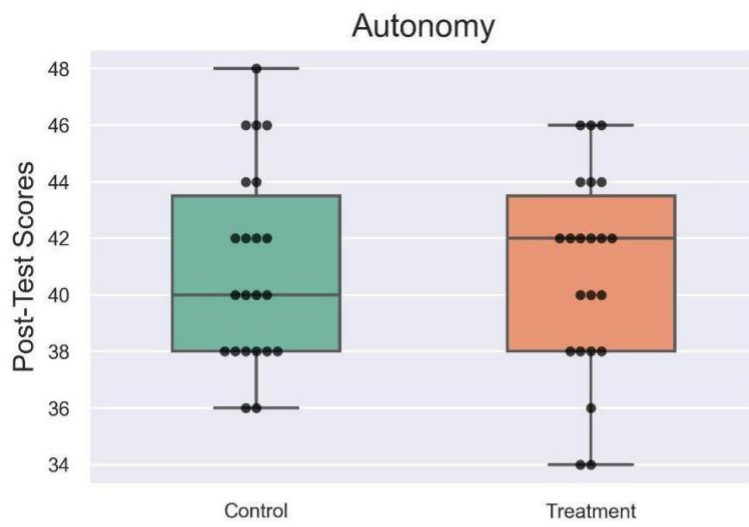
*Histograms of Survey Results for Students' Learning Experiences Regarding Learning Motivation, Autonomy, and Satisfaction*



Three independent-sample T-tests were conducted on our experimental sample of 44 participants to determine whether there was a significant difference in the learning experience between the comparison and the treatment group as measured by the survey result. Figure 13 below presents the distributions of the survey data for the three learning experiences. The boxplots in figure 8 indicate that the variance of data for the treatment and control groups in all three cases are similar. Clear higher means for the treatment groups are observable for learning motivation and satisfaction while this is less distinct for learning autonomy.

**Figure 13**

*Boxplots of Survey Results for Students' Learning Experiences Regarding Learning Motivation, Autonomy, and Satisfaction*



The researcher performed Shapiro-Wilk test and Levenes's test on the mean. The result indicates that the variances are not significantly different from each other (i.e., the homogeneity assumption of the variance is met) and that the requirements are met to perform the parametric t-test on the survey data.

**Table 16**

*The results of Shapiro-Wilk tests of Normality and Levenes's Test of Homoscedasticity*

Variable	Shapiro-Wilk		Levene's Test	
	Stat	p-value	Stat	p-value
Motivation	0.95	0.38	0.02	0.89
Autonomy	0.94	0.20	0.0	1.0
Satisfaction	0.95	0.26	0.22	0.64

Table 17 below shows the mean scores, standard deviations, independent t-test results, and effect sizes for comparing learning experience results between control and treatment groups. The results indicate that a significant improvement in the learning experience was achieved regarding the student's motivation (Cohen's  $d = 0.82$ ,  $t(42) = 2.71$ ,  $p\text{-value} = 0.0096 < 0.05$ ). However, the andragogical and CTML-enhanced instruction (i.e., the proposed approach of this study) was shown to have a small negative effect on learning autonomy (Cohen's  $d = -0.05$ ) and a medium effect (Cohen's  $d = 0.42$ ) on satisfaction. Neither of these effects was significant on either learning autonomy ( $t(42) = -0.17$ ,  $p\text{-value} = 0.87 > 0.05$ ) or satisfaction ( $t(42) = 1.43$   $p\text{-value} = 0.16 > 0.05$ ).

**Table 17**

*Independent T-test Results and Effect Sizes for Comparing Survey Result Between the Control Group and the Treatment Group*



Variable	Control Group (n=22)		Treatment Group (n=22)		t-test		Cohen's D
	Mean	SD	Mean	SD	T-test df=42	P value	Effect size D
Motivation	38.36	3.52	41.18	3.36	2.71	0.01	0.82
Autonomy	41.00	3.48	40.82	3.58	-0.17	0.87	-0.05
Satisfaction	39.45	3.16	40.82	3.19	1.43	0.16	0.42

### Qualitative Findings

Semi-structured individual interviews were used as the qualitative data collection method in this study. This section presents and interprets the findings of the third research question of this study.

#### Research question #3

How was the learning experience different between the comparison and treatment group as indicated by the interview?

This research question was to investigate students' learning experience in terms of learning motivation, autonomy, and satisfaction. The qualitative data allowed the researcher to obtain a deeper insight into how the learning experience is different between the conventional instruction and enhanced instruction based on a combined method of Andragogy and CTML. Two participants from the control group and another two participants from the treatment group voluntarily participated in the interview. The demographic information for the interviewees is provided in Table 18.

**Table 18**

*Demographic Characteristics of Individual Interviewees*

Group	Name	Gender	Ethnicity	Major	Education
-------	------	--------	-----------	-------	-----------

(Pseudonym)					
Control	Lisa	Female	Asian	Education	Graduate School
	Emma	Female	Asian	Education	Graduate School
Treatment	May	Female	Asian	Education	Graduate School
	Michael	Male	White	MBA	Graduate School

The individual interviews were conducted and captioned through Zoom. To compare the difference in the learning experience between the control group and the treatment group, the researcher designed three interview themes: learning benefit, learning engagement, and learning iteration. The learning benefit theme allowed the researcher to gain learners' overall satisfaction with the training. The learning engagement informed the researcher with in-depth knowledge about what learning initiative worked well in helping learners to learn. The learning iteration theme generated first-hand knowledge about what can be improved in the course design. Based on the three interview themes, the researcher developed six central questions that have been used to structure the interview. Table 19 below reports the findings of this research question.

**Table 19**

*Interview findings of the Control Group*

Interview Questions	Code	Group	Participants' Response
Q1: How was this training beneficial to you?	Learning Benefit	Control	Lisa: "Overall, I think this training is very helpful to refresh my knowledge and improve my Excel skills in a systematic way."
			Emma: "This training is very beneficial to me in terms of helping me to learn the fundamental skills and basic concepts in Excel"

Q2: What captured your learning interests in the training?	Learning Engagement	Treatment	May: "I think this training is definitely beneficial for my personal life and my work."
			Michael: "This training is very beneficial for me to learn the fundamental functions in Excel."
		Control	Lisa: "The whole training is just one hour, which makes me feel like I can just sit in front of my laptop and finish the training. And the learning objective is simple (achievable)."
			Emma: "I like the course because it is so flexible that I can complete the training anywhere. It also complements my schoolwork. I will do some research in the future, and I need to learn Excel."
Q3: What aspects of this course are helping you learn?	Learning Engagement	Treatment	May: "The training is short and concise. I can take it at my own convenience."
			Michael: "First, I think the course is really visually appealing. I also really like the videos. They are just two to three minutes long. Not overwhelming. You also chunked each video into a group of related concepts and added a preview of the sub-concept, which makes the content easy to digest. When demonstrating a feature, the video zoomed in, showing red rectangles, which really helped me to concentrate on the feature. And the summary at the end of each video told me what exact skill I just learned. I like the visual hints in the multiple-choice question as well. When clicking an option item, a check mark showed up, letting me know what I have selected."
		Control	Lisa: "The course content flows smoothly and is structured very well! There were three modules, which were aligned with the learning objectives. There is no content that distracts from the learning objectives. It only covered the exact amount of knowledge. Each video in the modules is around two minutes or three minutes long."
			Emma: "I really liked the exercise file and the videos. The videos are very clear. I can follow the videos with the exercise file you provided. I

			<p>also realized that at the end of each video, there was a summary of what I learned. There is a connection between the quiz and the content.”</p>
			<hr/>
Treatment			<p>May: “I really like the guided practice (simulation), in which I can perform the exercise step-by-step. I remember one of the exercises (simulation) asked me to input the format of data exactly like I would do in Excel. And it gave me instant feedback whether I did it correctly or not. I think it’s very interesting and easy to navigate.”</p>
			<hr/> <p>Michael: “I think all the content is helpful, the videos and exercise files gave me a clear demo, and allowed me to follow along. The guided practice (simulation) guided me to execute a task step-by-step within the course. I think the mind map is helpful, too. If I forget something, I don’t need to take the course again, and I can just quickly scan the mind map to find the steps (procedures). There were additional learning resources provided at the end of the course. I am very interested in keep learning it.”</p>
			<hr/>
Q4: What do you wish to be changed in the course?	Learning Iteration	Control	<p>Lisa: “I wish the multiple-choice questions can be changed into a project-based assessment, so I can learn how to manipulate spreadsheets in real-life situations. Additionally, I think it’s hard to perform the self-practice added into each end of the video voluntarily, as I have to switch the Canvas (learning platform) into Excel.”</p>
			<hr/> <p>Emma: “Maybe add some activities, like games, drag and drop, to make it more interesting and interactive.”</p>
			<hr/>
Treatment			<p>May: “Maybe a real project for assessment. The multiple-choice questions are good to check my understanding, but a real project that asks me to apply what I learned in a real project will be very interesting. For example, at the end of each video, you can give a hands-on task, like give me a scenario and ask me to create a chart. That will be very interesting.”</p>
			<p>Michael: “It will be very helpful if you can add a</p>

brief instruction at the beginning of the guided practice. It is my first time doing this kind of activity, and I didn't know what to do at the beginning. But I quickly figured that out.”  
Additionally, if you can enlarge the screens in the guided practice, like zoom-in the targeted area that would be very helpful!

Q5: How might Excel training benefit you?	Learning Benefit	Control	<p>Lisa: Participant A: I think it will benefit me long-term as I will need to use it no matter what industry I will be working in.</p> <hr/> <p>Emma: I might use it to run some data for my future research.</p>
		Treatment	<p>May: “I think next time when I place an order with my friends, I will be able to use Excel to calculate who spent how much money. Also, I will be able to use Excel to calculate my students’ grades!”</p> <hr/> <p>Michael: “I am doing a project for the International Marketing course. Excel helps me organize my data for further analysis”</p>
		Control	<p>Lisa: “This training is very easy to follow, and I didn’t encounter any difficulties or barriers in this training.”</p> <hr/> <p>Emma: “I have encountered several technical difficulties, like playing a video in the course. If there is a chatting box that can allow me to report the errors or interact with the instructor for technical assistance, that will be very helpful.”</p>
		Treatment	<p>May: “Overall, it’s very easy to follow! But in the guided practice, I probably did not follow the instruction and clicked somewhere else. It gave me an error message that I did it wrong, but I didn’t know how I did it wrong.”</p> <hr/> <p>Michael: “I didn’t encounter any major difficulty in the course. But I think a brief instruction about how to navigate the course and the guided practice will be very helpful. It’s my first time learning this interface (storyline). Even though I can intuitively figure out how to navigate, a</p>

In terms of the learning benefit, participants from both groups found their training beneficial in helping them to learn or improve the skills of Excel. The participants from the control group believed the conventional training was beneficial as it helped them to store knowledge for the future, while the participants from the treatment considered the training designed based on Andragogy and CTML beneficial as it helped them to solve real-life problems. One participant, Lisa, from the control group, thought the conventional training was beneficial because of the importance of the subject matter. The other participant from the control group, Emma, claimed that the conventional training with her future research work. May from the treatment group thought the training designed based on Andragogy and CTML benefited her personal life and her work as she said, “next time when I place an order with my friends, I will be able to use Excel to calculate who spent how much money, also I will be able to use Excel to calculate my students’ grades”. Another participant from the treatment group, Michael, considered the training designed based on Andragogy and CTML training benefited his current task of a final project for the International Marketing course.

Regarding learning engagement, participants were engaging with different learning initiatives. Participants who took the conventional training pointed out the macro learning design and the well-structured course materials-the exercise file, videos, and the quiz-engaged their learning. For example, Lisa stated that: “The whole training is just one hour, which makes me feel like I can just sit in front of my laptop and finish the training. And the learning objective is simple (achievable). The course content flows smoothly and is structured very well! There were three modules, which were aligned with the learning objectives. There is no content that distracts from the learning objectives. It only covered the exact amount of knowledge. Each video in the

modules is around two minutes or three minutes long”. Emma said that: “I really liked the exercise file and the videos. The videos are very clear. I can follow the videos with the exercise file you provided. I also realized that at the end of each video, there was a summary of what I learned. There is a connection between the quiz and the content”. In addition to the micro learning design and the flexible learning schedule, participants who took the training designed based on Andragogy and CTML considered hands-on activities and enhanced multimedia learning materials captivating. May stated that the flexible learning schedule worked for her and the simulation in which she performed the exercise step-by-step really maintained her learning interests. Michael thought the macro learning experience with enhanced multimedia design - visuals, videos, and mind maps - is interesting. He stated that: “First, I think the course is really visually appealing. I also really like the videos. They are just two to three minutes long and not overwhelming. You also chunked each video into a group of related concepts and added a preview of the sub-concept, which makes the content easy to digest. When demonstrating a feature, the video zoomed in, showing red rectangles, which really helped me to concentrate on the feature. And the summary at the end of each video told me what exact skill I have just learned. I like the visual hints in the multiple-choice question as well. When clicking an option item, a check mark showed up, letting me know what I have selected.”

The learning iteration theme questions generated first-hand knowledge about what can be improved in the course design. Participants who took the conventional instruction suggested changing the multiple-choice questions into a project-based assessment. In addition, Lisa reported the difficulty of performing the self-practice in Excel while learning in the Learning Management System. Emma suggested adding interactive activities. In the training, designed based on Andragogy and CTML, the self-practice was transformed into a simulation in the

eLearning, in which the learners can perform Excel tasks step-by-step in a simulated interface without navigating off the Learning Management System. This learning initiative made learning easier to navigate and more interactive. The participants in the andragogy and CTML enhanced training revealed the suggestion of changing the multiple-choice quiz into a project-based exercise and the suggestion of adding a brief instruction about how to navigate the course and the guided practice at the beginning of the guided practice.

In a nutshell, the interviews reported different learning experiences regarding three interview themes: learning benefit, learning engagement, and learning iteration. Participants from both groups found their training beneficial with control group participants believing they will need to use the newly acquired knowledge - Excel - in the future and the treatment group participants positioned themselves using the new skill to solve real-life problems that currently existed in their life. Regarding learning engagement, participants who took the conventional training pointed out the macro learning design and the well-structured course materials-the exercise file, videos, and the quiz-engaged their learning. Participants from the treatment group thought the simulation and the enhanced multimedia design - visuals, videos, and mind maps - are really interesting. When it comes to the learning iteration, participants who took the conventional instruction suggested changing the multiple-choice questions into a project-based assessment, maintaining a single learning platform, and adding interactive activities. The participants in the andragogy and CTML-enhanced training revealed the suggestion of changing the multiple-choice quiz into a project-based exercise and adding a brief learning navigation instruction.

### **Summary**



The purpose of this study was to investigate the effectiveness of the combined method of andragogy and cognitive load of multimedia learning (CTML) in (1) enhancing learning results; and (2) optimizing students' learning experience regarding learning motivation, autonomy, and satisfaction in T & D technical training programs of higher education. This study utilized a mixed-method design of quantitative and qualitative methods. The quantitative data were collected through two instruments in both control (n=22) and the treatment group (n=22). The first quantitative instrument was a quiz, which was implemented to measure students' prior knowledge and learning results. The second quantitative instrument is a survey, which was distributed to investigate students' learning motivation, autonomy, and satisfaction. Qualitative data (n=4) were collected through semi-structured individual interviews from both control and treatment groups to obtain an in-depth perspective of students' learning experiences. Both statistical and practical significance of quantitative results were computed by employing a one-tail two-sample t-test and Cohen's d-test.

The first research question was to investigate the extent of the difference between the learning results of the control and the treatment groups. The pre-test result ( $t = 0.17$ ,  $p = 0.87 > 0.05$ , Cohen's  $d = 0.05$ ) indicates that there is no difference in prior knowledge between the participants who took conventional instruction and those who took the andragogy and CTML enhanced instruction. The post-test result,  $t(42) = 2.65$   $p\text{-value} = 0.01 < 0.05$ , indicates a significant mean difference in post-test data between the two groups and the effect size is large ( $d = 0.8$ ). In terms of the gained scores between the pre-test and the post-test, the scores for the control group ( $M = 41.28$ ,  $SD = 8.43$ ), increased less than the treatment group ( $M = 48.48$ ,  $SD = 12.55$ ). The t-test result ( $t(42) = 2.23$   $p\text{-value} = 0.3 < 0.05$ ) indicates a significant mean difference between the two groups and the effect size is medium ( $d = 0.67$ ). Thus, this study suggested that andragogical and

CTML-enhanced instruction is very effective in improving students' learning in the self-paced technological program.

The second research question investigated the extent of the difference in the learning experience between the comparison and the treatment groups regarding learning motivation, autonomy, and satisfaction. The results indicate that a significant improvement in the learning experience was achieved with regard to the student's motivation (Cohen's  $d = 0.82$ ,  $t(42) = 2.71$ ,  $p\text{-value} = 0.0096 < 0.05$ ). However, the andragogical and CTML enhanced instruction (i.e., the proposed approach of this study) was shown to have a small negative effect on learning autonomy (Cohen's  $d = -0.05$ ) and a medium effect (Cohen's  $d = 0.42$ ) on satisfaction. Neither of these effects was significant on either learning autonomy ( $t(42) = -0.17$ ,  $p\text{-value} = 0.87 > 0.05$ ) or satisfaction ( $t(42) = 1.43$ ,  $p\text{-value} = 0.16 > 0.05$ ).

The third research question was to investigate how the learning experience was different between the comparison and the treatment group. The interviews reported different learning experiences regarding three interview themes: learning benefit, learning engagement, and learning iteration. Participants from both groups found their training beneficial with control group participants believing they would need to use the newly acquired knowledge (Excel) in the future and the treatment group participants positioning themselves using the new skill to solve real-life problems that exists in their life currently. Regarding learning engagement, participants who took the conventional training pointed out the macro learning design and the well-structured course materials-the exercise file, videos, and the quiz-engaged their learning. Participants from the treatment group thought the simulation and the enhanced multimedia design - visuals, videos, and mind maps - were really interesting. When it comes to the learning iteration, participants who took the conventional instruction suggested changing the multiple-choice questions into a project-based

assessment, maintaining a single learning platform, and adding interactive activities. The participants in the andragogy and CTML enhanced training revealed the suggestion of changing the multiple-choice quiz into a project-based exercise and adding a brief learning navigation instruction.

## **CHAPTER V**

### **DISCUSSION, IMPLICATIONS, CONCLUSION, AND RECOMMENDATIONS**

*“Life is the art of drawing sufficient conclusions from insufficient premises”.*

Samuel Butler

#### **Overview**

The purpose of this study was to investigate the effectiveness of the combined method of Andragogy and Cognitive Theory of Multimedia Learning (CTML) in enhancing learning results and optimizing students’ learning experience in an asynchronous Excel training program in higher education. This chapter reports the summary of the study and the key findings associated with the research questions. Then the limitations of the study will be discussed, followed by the implications for educational practitioners and leaders. Key recommendations for future research mark the closure of this chapter.

#### **Summary of the Study**

In the modern higher educational system, technology permeated almost all the provisions of educational processes and transformed individual learning transactions. Empirical evidence reveals students’ challenges and discomfort in using technology to fulfill learning activities, such as participating in the online discussion, learning at a distance, and engaging in technology-based assignments (e.g., Ilonga et al., 2020; Stenhoff et al., 2020; Lynn et al., 2020). Moreover, beyond

the campus, the work environment is more and more driven by technology. Although students in the 21st century are dependent on current technology, there is still a technological gap between what is taught in school and what is needed for success in today's workplace (Percival, 2018).

Given students' skill gaps in the digitized campus and the employment market, technical training is of high value and in high demand in helping them to develop the skills necessary to carry out schoolwork and be prepared for the real-world work environment driven by technology. While research regarding the training provisions such as formal in-service, mentoring, workshops, peer observations, and professional learning community has been ongoing for several decades, the investigation on the self-paced eLearning is still in the early stage. Multimedia instruction, grounded in the Cognitive Theory of Multimedia Learning (CTML), is one of the dominant representational formats for software training in T&D. There have been studies focused on the effectiveness of demonstrated video in technical training (i.e., Chen & Yang, 2020; Van der Meij, 2019). However, the effectiveness of other multimedia formats, such as mind maps and simulations that have been demonstrated to be effective in other subject matter, have not been investigated in software training in the T&D of higher education. Additionally, previous studies use a pedagogical paradigm and fail to take into account adults' unique learning characteristics. Thus, the researcher proposed a combined method of andragogy and CTML in the self-paced software training program to leverage learning results and optimize the learning experience.

This dissertation is buttressed on two of the scientific learning theories that exert significant value in education: (a) Knowles's (1989, 2015, 2020) Andragogy and (b) Mayer's (2003, 2020) cognitive theory of multimedia learning. Knowles's andragogy indicates that (I) Adults need to know the objective of learning a subject matter before undertaking its learning; (II) "Adults have a self-concept of being responsible for their own decisions and for their own lives, which helps

them to make the transition from dependent to self-directing learners”; (III) Adults participate in learning activities with a great reservoir of life experience and new information is processed through the lens of life experiences; (IV) As adults mature, they tend to learn knowledge associated with their particular social roles and developmental tasks; (V) “In contrast to children’s and youths’ subject-centered orientation to learning (at least in school), adults are life-centered (or task-centered or problem-centered) in their orientation to learning; and (VI) It is the intrinsic motivation that drives adults to learn, despite the responsiveness to external incentives (Knowles et al., 2020, pp. 44-46).

The second theory of prominence factoring into this study is the CTML, which has been popularized by Richard E. Mayer and others (e.g., Mayer & Moreno, 1998; Mayer, 2001; Mayer, 2003); Mayer & Fiorella, 2014; Mayer, 2020). This theory provides evidence-based insight on transforming knowledge information into a multimedia-based learning representation, which enables learners to process information effectively with limited cognitive capacity. The researcher believes that higher education learners can comprehend and transfer technical skills when the instruction provides two or more modalities, such as the visual modality and the auditory modality, at the same time rather than only through one of the modalities alone.

The researcher of this study drew on the Andragogy principles and the CTML to shape the design, development, and evolution of self-paced online learning. Strategically incorporating Andragogy allowed the researcher to build sustainable and flexible technical training programs for learners in higher education. Incorporating CTML principles enables the learners to eliminate this extraneous processing and thus make the best use of the limited processing capacity to process the information relevant to the instructional goals.

The purpose of this study was to investigate the effectiveness of the combined method of Andragogy and CTML in enhancing learning results and optimizing students' learning experience in an asynchronous Excel training program in higher education. The researcher designed a conventional Excel training for the control group, which included video tutorials, exercise files, and text-based handouts and an Andragogy and CTML enhanced training for the treatment group, which included video tutorials, simulated hands-on activities, and visual-based mind map handouts. The learning experience for both groups was designed on Storyline 360, an industry-standard eLearning authoring tool. A SCORM package, exported from Storyline 360, was uploaded into Canvas, the learning management system that the university has been using for years, for students to take the self-paced training at their convenience.

This study utilized a mixed method design and was conducted in a private religiously affiliated university in the US. The combined method of Andragogy and cognitive load of multimedia learning (CTML) is the independent variable for this study. The first dependent variable for this study is the learning outcome, which was measured by the multiple-choice quiz. The second variable for this study is the learning experience, which was measured by the learning motivation, satisfaction, and autonomy in the Likert scale of a survey. In addition, semi-structured individual interviews were used as the qualitative data collection method to obtain a deeper insight into how the learning experience is different between conventional instruction and enhanced instruction based on Andragogy and CTML.

To investigate the effectiveness of the proposed strategy on students' technical skill acquisition, the study investigated the following research questions:

1. To what extent was there a difference in the learning outcomes between the comparison and the treatment group?

- a. To what extent was there a difference in the pre-test score between the comparison and the treatment?
  - b. To what extent was there a difference in the post-test score between the comparison and the treatment group?
  - c. To what extent was there a difference in the gained score between the comparison and the treatment group?
2. To what extent was there a difference in the learning experience between the comparison and the treatment group?
  - a. To what extent was there a difference in learning motivation as measured by the Likert scale of a survey?
  - b. To what extent was there a difference in learning autonomy as measured by the Likert scale of a survey?
  - c. To what extent was there a difference in learning satisfaction as measured by the Likert scale of a survey?
3. How was the learning experience different between the comparison and the treatment group as indicated by the interview?

### **Summary of Findings**

This study utilized a mixed-method design of quantitative and qualitative approaches. Both statistical and practical significance of quantitative results were computed by employing the one-tail two-sample t-test and Cohen's d-test. All requirements of parametric tests - i.e., independence of sampling, sampling randomness, outliers, normality of distributions, and the homogeneity of variances - have been carefully checked for the data before the performance of statistical tests.

The first finding of this study was the effectiveness of the interventional training designed with a combined method of Andragogy and CTML in improving students' learning outcomes in a self-paced technical training program. The pre-test result, ( $t(42) = 0.17$ ,  $p = 0.87 > 0.05$ , Cohen's  $d = 0.05$ ) indicates that there was no statistical difference in the prior knowledge between the two groups. The post-test result,  $t(42) = 2.65$ ,  $p\text{-value} = 0.01 < 0.05$ , indicates a significant mean difference, and the effect size is large ( $d = 0.8$ ), which indicates the proposed approach (i.e., andragogical and CTML) is more effective in improving learning result compared with the conventional instruction. Additionally, the T-test result for the gained score ( $t(42) = 2.23$ ,  $p\text{-value} = 0.03$ ) indicates that there exists a significant difference between the two groups, and the effect size is medium (Cohen's  $D = 0.67$ ).

The second finding of the research was that the Andragogy and CTML-enhanced training had a significant effect on improving students' learning motivation, a slight effect on improving learning satisfaction (yet not statistically significant), but no effect on improving learning autonomy compared with the conventional training in a self-paced technical training program. Specifically, a significant improvement in student's motivation was observed ( $t(42) = 2.71$ ,  $p\text{-value} = 0.0096 < 0.05$ ) and the effect size was large (Cohen's  $d = 0.82$ ). However, the Andragogical and CTML enhanced instruction (i.e., the proposed approach of this study) was shown to have no statistical significance in improving learning autonomy ( $t(42) = -0.17$ ,  $p\text{-value} = 0.87 > 0.05$ , Cohen's  $d = -0.05$ ) or satisfaction ( $t(42) = 1.43$ ,  $p\text{-value} = 0.16 > 0.05$ , Cohen's  $d = 0.42$ ).

The third finding of this research was associated with the in-depth perspective on the learning experience regarding the conventional instruction and the andragogy and CTML-enhanced instruction: (1) learners found the Andragogy and CTML enhanced training beneficial



as it met their current or future needs; (2) learners in both groups were engaged in the micro-learning experience that was organized coherently and logically. Learners in the treatment group found the multimedia-based exercises (i.e., simulations) and handouts (i.e., mind maps) interesting; (3) participants in both groups suggested substituting the multiple-choice quiz with a project-based assessment. Additionally, adding brief instructions about how to navigate the course and the simulation was recommended by the learners in the treatment group.

### **Limitation**

Even though the researcher strived to minimize the range of scope of limitations through the research process, several limitations remain due to external reasons that the researcher could not control. In this section, the researcher acknowledged four limitations and explained the impact of the research findings.

The first limitation lay in the broadness of the first research question - to what extent was there a difference in the learning outcomes between the comparison and the treatment group? Assessment of learning outcomes helps determine the instructional effectiveness of instruction (Mayer, 2020, p. 229). Mayer claims that learning outcomes can be assessed through learners' knowledge comprehension and skill transfer (Mayer, 2020, p. 239). In this study, multiple-choice quiz questions were used to measure learners' knowledge comprehension and skill transfer. However, the researcher only examined the learner's overall learning outcome and did not dive into the learning outcome of knowledge comprehension and skill transfer separately due to the lack of a Learning Record Store of the university Learning Management System (LMS). The quiz questions were embedded in the Sharable Content Object Reference Model (SCORM) on an eLearning authoring tool Storyline 360. The SCORM automatically graded the learner's quiz and sent the final score of the quiz to Canvas - LMS. To track learners' performance on each quiz

question, an LRS is needed to receive the learning experience data. Given that the LRS was not available, the researcher only received learners' final scores on the multiple-choice quiz and could not analyze students' learning outcomes on knowledge comprehension and skill transfer.

The second limitation was associated with the quantitative data collection method. The researcher utilized multiple-choice quizzes as the first quantitative instrument which aimed to investigate learners' learning outcomes. There were two purposes of utilizing this instrument: (1) to control the eLearning experience to 50 to 60 minutes, so learners can complete with one sit; (2) to make the learning outcome subjective as there was no objective rubric involved to grade the quiz questions. This instrument is a strong indicator of how well learners mastered Excel, but the result cannot be directly translated into learners' Excel performance in real-life projects. The second quantitative instrument was a survey on Qualtrics, designed to measure learning motivation, autonomy, and satisfaction. However, the self-report answers might be exaggerated. Various biases of the respondents may affect the result. Respondents might favorably report their feeling due to the appreciation of the researcher's effort in designing the free training. Given that the objective instruments (i.e.: eye-tracking, log-file mining, and brain activity scanning) were not available, the self-report data in a survey was the sole data the research obtained.

The third limitation is the sample. Given that the training is not required by either the university or the instructor of the students, voluntary participation constituted the convenience sample for this study. 70 participants volunteered to participate in this study. However, there were only 44 participants who completed the training by the time the researcher conducted the data analysis. Even though the samples in each group ( $N = 22$  in the control group;  $N = 22$  in the treatment group) met the assumptions of the one-tail two-sample t-test (i.e.: samples in each group were independent based on random selection; the data in each group follow (approximately) a

normal distribution; the variances of data are approximately equal across groups), the sample might limit the generalizability of the study result. The participants were from a private religiously affiliated university on the west coast of the U.S., which might be geographically limited to generating the result for a population outside of the university where the study took place. Furthermore, because of the relatively small sample size, the researcher only investigated the difference in the learning results between the control group and treatment groups. The learning outcome result and learning experience result were not analyzed among ethnic groups and genders.

### **Discussion of Findings**

With the ubiquity of technology platforms used in the modern educational system and the workplace, an effective training and development program designated to help university students to establish technical literacy is of high demand and value. The purpose of this study was to investigate the effectiveness of the combined method of Andragogy and Cognitive Theory of Multimedia Learning (CTML) in enhancing learning results and learning experience (i.e., learning motivation, learning autonomy, and learning satisfaction) in an asynchronous Excel training program in higher education. Further, this study investigated the difference in the learning experience between the participants who took the conventional training and the Andragogy and CTML enhanced training. This section discusses the findings of each research question in connection to the findings of previous research in the context of T & D.

#### **Finding 1**

The first finding of this study was the effectiveness of the interventional training designed with a combined method of Andragogy and CTML in improving students' learning outcomes in

the post-test ( $t(42) = 2.6$ ;  $p\text{-value} = 0.01 < 0.05$ ; Cohen's  $D = 0.8$ ) and in maximizing the gained score ( $t(42) = 2.23$ ,  $p\text{-value} = 0.03 < 0.05$ ; Cohen's  $D = 0.67$ ).

Given that very few studies investigated the effectiveness of the combined method of Andragogy and CTML, the observation of this study is not directly analogous to the findings of previous literature. However, this finding agrees with the previous research that studied the effects of the individual method of the Andragogical model (i.e., Rathner & Schier, 2020) and CTML (Alpizar et al., 2020; Mayer, 2019; Khacharem et al., 2020; Sauli, 2018; Schroeder and Cencki, 2018;). For example, in a study conducted on two advanced physiology subjects (i.e. advanced neuroscience; cardiorespiratory and renal physiology), Rathner and Schier (2020) observed statistically significant improvements in students' final grades from both subjects in the flipped classroom grounded on Andragogy. In a meta-analysis of 29 experiments on 2726 participants, Alpizar et al. (2020) found a 0.38 effect size, with a statistical significance of  $p < 0.01$ , indicating the effectiveness of incorporating multimedia principles in enhancing learning outcomes. The result of this study further supported the effectiveness of the Andragogy and CTML principles in facilitating learning results.

The researcher believes the positive effect of the combined method of Andragogy and CTML was closely associated with the seamless incorporation of needs analysis in the learner and the creative integration of the multiple multimedia modalities. Knowles et al. (2020) indicated that to utilize the Andragogical model, one needs to perform an Andragogical learner analysis. Given the wide range of backgrounds, educations, experiences, interests, motivations, and abilities that characterize the adult participants of this study, the researcher made lessons highly relevant to the learners' goals, engaged learners through problem-centered exercises, and established contextualized tasks for knowledge transfer.

Furthermore, multiple multimedia modalities might be another reason factoring into the effectiveness of the treatment in this study. Xie et. al. (2019) found that presenting coordinated visual and auditory cues also resulted in a better performance than presenting only a visual cue or auditory cue alone or presenting the two cues in unmatched or unsynchronized ways. Students in this study may benefit from coordinated visual and auditory cues when interacting with the micro screencast videos. The simulated activities, which allowed learners to actively engage in the cognitive processing of information, and the mind maps, which constructed a coherent mental representation of their learning experiences, are other variables factoring into the improved learning outcomes in this study.

## **Finding 2**

The second finding of the research was that the interventional training designed with a combined method of Andragogy and CTML had a significant effect on improving students' learning motivation, a slight effect on improving learning satisfaction, but no effect on improving learning autonomy compared with the conventional training in a self-paced technical training program. The researcher hereby discusses the results that align with previous research and speculates the different findings.

Previous literature has informed a eureka of discoveries regarding the validity and effectiveness of Andragogy in promoting learning motivation and satisfaction. For example, in the qualitative research investigating the issue of the learning process via the Andragogical approaches of seven adult learners, the semi-structured interview indicated that the Andragogical approaches positively affect students' learning motivation and satisfaction (Ibrahim, 2022). Kaddoura and Husseiny (2021) reported similar results in a study conducted among 140 university students in

the Basics of Information Security course. The questionnaire result observed a noticeable student motivation and satisfaction regarding the Andragogical approach.

The previous study has also shown the effectiveness of CTML in promoting students' motivation and satisfaction. For example, in a study conducted among 575 fifth- and sixth-graders, Lindner et. al., (2022) observed higher metacognitive and satisfaction ratings for science test items designed with multimedia principles. Wang, et. al. (2021) revealed a similar result in a study conducted among 60 students in online learning. The result of the eye tracker and survey instrument showed that the interactive graphic organizer, designed in alignment with CTML principles, promoted deep processing and active engagement in the cognitive processes and thus led to better learning outcomes and experiences.

In contrast to the finding of this study, previous literature showed that instructions grounded in the theoretical framework of Andragogy developed students' learning autonomy, which has the potential to benefit all the subject matter learning in higher education. Mann and Willans (2020) found that “students were able to learn how to become self-directed learners when lecturers ‘tailored’ teaching to the student's needs, taking into consideration their state of mind, ability to plan their work, developing adeptness at engaging in mathematical activities, and assistance received in evaluating their learning outcomes”. The study of Lewis et al., (2018) supported this finding as well and indicated that a flipped classroom grounded in adult learning theory fostered self-directed, active learning, and deeper learning in the third-year surgery clerkship.

There are several possible reasons why the combined method of Andragogy and CTML had no discernible effect on students' learning autonomy. As preparatory skills for learning success, learning autonomy is a competency that “students must learn and master, along with any

specific subject-based content” (Dant et al., 2021; Mann and Willans, 2020). In higher education, this is when a student: “is mindful of and asserts control over their thoughts; can understand what is required to plan their learning; has a metacognitive understanding of their actions while engaged in their study; and has the knowledge and tools to evaluate and revise their study habits and plans” (Mann and Willans, 2020). In situations where learners feel secure as members of a community, they are more likely to be involved in relatedness and autonomous learning will grow (Han, 2021). Individual isolated learning might be one of the reasons why the improvement of learning autonomy was not observed in this study.

### **Finding 3**

The semi-structured interviews in this study revealed: (1) learners found the Andragogy and CTML enhanced training beneficial as it met their current or future needs; (2) learners in both groups (i.e., learners who took the conventional training and those who took the Andragogy and CTML enhanced training) were engaged in the [micro-learning](#) experience that was organized coherently and logically. Learners who took the Andragogy and CTML enhanced training found the multimedia-based exercises (i.e., simulations) and handouts (i.e., [mind maps](#)) interesting; (3) participants in both groups suggested substituting the multiple-choice quiz with a project-based assessment. Additionally, students who took the combined-method training (i.e., the proposed approach of this study) suggested adding brief instructions about how to navigate the course. This is particularly important in an asynchronous learning environment.

First and foremost, the qualitative results indicated that technical training based on a combined method of Andragogy and CTML could play a pivotal role in supporting the professional goals of university students. This finding is in line with the results of interpretive phenomenological research that aimed to explore the relationship between service learning and

career preparation using Knowles' Andragogy as a theoretical framework (Roe, 2022). In this study, Roe (2022) found that integrating Andragogy in the service-learning program for the young adult learner is (a) a professional experience itself and an opportunity to further prepare for graduate school students' future careers and (b) a genuine way for students to develop skills and self-efficacy important to their career trajectory. This finding is further supported by the studies of Ring et al., (2019) and Sato et al. (2020), which indicated that an Andragogical-based program transforms both participants' professional lives and the professional service they provide.

Furthermore, the qualitative finding showed that learners could be engaged in micro-learning experiences with multimedia-based initiatives. This may be attributed to the reduced workload and the reduced cognitive processing load. In a study conducted in a flipped classroom, Rathner and Schier (2020) found that pre-recording and chunking the lectures reduced the time for content delivery in both subjects by one-third, which reduced the student workload and facilitated learning engagement. The researcher of this study considered that the essential content of Excel training may be complex for the learner to the point of overwhelming the learner's limited processing capacity. Thus, in addition to designing the learning initiatives based on CTML principles for reducing extraneous processing, the researcher broke the complex topic into manageable segments whose pace can be controlled by the learner. This may facilitate learners' engagement with the content as it "allows the learner to build a mental representation of one part of the material before moving on to the next one" (Mayor, 2021). The finding also revealed learning interest in the simulations and mind maps provided in the Andragogy and CTML enhanced training. Simulation allows learners to interact with Excel in a simulated environment as if they do in reality. It might be the fact that it creates a safe and flexible environment, where wrong attempts would not be punished, that lowered the learner's affective filter and thus, enhanced the



learning engagement. The mind maps constructed a coherent mental representation of their learning experiences and thus helped to transfer the newly acquired knowledge into long-term memory. The researcher believes that the off-loading process promoted learners' interest and factored into the improved learning engagement in this study.

Moreover, this finding indicated that project-based assessment could be a valid substitute for multiple-choice questions and course navigation should be addressed in asynchronous learning. Project-based assessment, allowing students to put newly acquired knowledge into practice, could enhance learners' ability to use the knowledge to perform real-life tasks. In a study conducted in a 5-week asynchronous online graduate-level research methods course in the field of Communication Science and Disorders, Randazzo et al., (2021) found that project-based learning resulted in higher research self-efficacy and greater engagement with course content. As a learning initiative, assessment promotes active representation of the learning materials and can improve the critical and creative thinking skills of the learners (Yustina, et al., 2020). Thus, the researcher claims that substituting multiple-choice questions with project-based assessment might further improve learners' learning experience (especially motivation) in an Andragogy and CTML intervention.

Last, the qualitative finding indicated that learners reported discomfort navigating the self-paced learning designed on an industry-standard eLearning authoring tool - Storyline 360. Previous empirical evidence revealed students' challenges and discomfort in using technology to fulfill learning activities, such as participating in the online discussion, learning at a distance, and engaging in technology-based assignments (e.g., Ilonga et al., 2020; Stenhoff et al., 2020; Lynn et al., 2020). The course navigation was the main discomfort learners revealed in this study. This might be attributed to the learners' lack of experience learning in a fully online modality designed

as a cutting-edge SCORM package with Storyline 360. The researcher believes concise course navigation will improve learners' meta-technological ability while learning technological skills in self-paced T & D programs. This will reduce learners' anxiety when learning individually and thus improve learning engagement and reduce drop-off rates.

To design a learner-friendly course navigation, the researcher suggests starting with a course tour or map, labeling learning initiatives with their metacommunicative meaning, and providing detailed instructions for the assignment. For some novel activities that learners may not have experienced before (i.e., simulation in this interventional training), a virtual tour guide or risk-free exercise that navigates learners to interact with the activity step by step will lead to a more effective and meaningful learning experience.

### **Conclusions**

The purpose of this study was to investigate the effectiveness of the combined method of Andragogy and CTML in enhancing learning results and learning experience (i.e., learning motivation, learning autonomy, and learning satisfaction) in an asynchronous Excel training program in higher education. Further, this study investigated the difference in the learning experience between the participants who took the conventional training and the Andragogy and CTML enhanced training.

This study utilized a mixed-method design. There were 22 students in the control group, who received the conventional training, which included unedited micro-video tutorials, exercise files, and text-based handouts, and 22 students in the treatment group, who received the Andragogy and Multimedia enhanced training, which included edited micro-video tutorials, simulations, and visual-based mind map handout. The learning experience for both groups was designed on Storyline 360, an industry-standard eLearning authoring tool. A SCORM package, exported from

Storyline 360, was uploaded into Canvas, the learning management system that the university has been using for years, for students to take the self-paced training at their convenience.

To fulfill the purpose of this study, the multiple-choice quiz was used as the first quantitative instrument to measure students' learning outcomes. A pre-test was conducted at the beginning of the training to assess students' prior knowledge. The same test was conducted at the end of each training module to measure students' learning results. The survey on Qualtrics was used as the second quantitative instrument to measure students' learning experience regarding learning motivation, satisfaction, and autonomy. The participants were asked to rate the degree of their learning motivation, autonomy, and satisfaction in the 5-point Likert questions, with 1 being strongly disagreed and 5 strongly agree (i.e., 1 = strongly disagree; 2 = disagree; 3 = neither disagree nor agree; 4 = agree; 5 = strongly agree). The results were coded in the way that each point of the Likert scale was worth 2 points (i.e., strongly disagree = 2 points; disagree = 4 Points; neither disagree nor agree = 6 points; agree = 8 points; strongly agree = 10 points). The semi-structured individual Zoom interview was used as the qualitative method to examine the difference in the learning experience between the control group and the treatment group. The researcher designed six interview questions that were centered on three themes: learning benefit, learning engagement, and learning iteration.

The results of the first quantitative instrument - multiple choice question - in this study indicated that the combined method of Andragogy and CTML was effective in improving students' learning results and motivation experience in the asynchronous Excel learning program. Specifically, the pre-test result, ( $t = 0.17$ ,  $p = 0.87 > 0.05$ , Cohen's  $d = 0.05$ ) indicates that there is no difference in prior knowledge between the participants who took conventional instruction and those who took the andragogy and CTML enhanced instruction. The post-test result,  $t(42) = 2.65$

p-value =  $0.01 < 0.05$ , indicates a significant mean difference in post-test data between the two groups and the effect size is large ( $d = 0.8$ ). In terms of the gains between the pre-test and the post-test, the result ( $t(42) = 2.23$ , p-value =  $0.03 < 0.05$ ) suggests a statistical significance in the mean difference and the effect size is medium (Cohen's  $D = 0.67$ ).

The results of the second quantitative instrument - the survey - indicated that a significant improvement in the learning experience was achieved concerning the student's motivation and the effect size was big (Cohen's  $d = 0.82$ ,  $t(42) = 2.71$ , p-value =  $0.0096 < 0.05$ ). However, the Andragogy and CTML enhanced instruction had no significant effect in improving learning autonomy. On the contrary, it slightly impaired students' learning autonomy (Cohen's  $d = -0.05$ ), but the effect was not significant ( $t(42) = -0.17$ , p-value =  $0.87 > 0.05$ ). The result also suggested that there was an improvement in students' learning satisfaction, but the significance was not statistically important (Cohen's  $d = 0.42$ ,  $t(42) = 1.43$  p-value =  $0.16 > 0.05$ ).

The results of the qualitative instrument indicated that Participants from both groups found their training beneficial. Regarding learning engagement, participants who took the conventional training pointed out the macro learning design and the well-structured course materials-the exercise file, videos, and the quiz-engaged their learning. Participants from the treatment group thought the simulation and the enhanced multimedia design - visuals, videos, and mind maps - are really interesting. When it comes to the learning iteration, participants who took the conventional instruction suggested changing the multiple-choice questions into a project-based assessment, maintaining a single learning platform, and adding interactive activities. The participants in the andragogy and CTML enhanced training revealed the suggestion of changing the multiple-choice quiz into a project-based exercise as well, in addition to adding a brief learning navigation instruction.

### **Implications for Educational Practice**

Technical training plays an important role in complimenting students' academic learning and preparing them for the workforce. This research developed a new framework for designing online self-paced technical-training programs based on the Andragogy and CTML principles. The data analysis result revealed that the students who received the interventional instruction designed with Andragogy and CTML principles obtained better learning outcomes and expressed higher learning motivation. This study exerted significant practical implications for stakeholders such as teachers, students, instructional designers, educational leaders, university institutions, and corporations.

First, this study may help educational practitioners to effectively utilize the Andragogical principles to address the unique contextual obstacles of young adult learners in online learning settings. With the ubiquity of technology and the internet, online learning has burgeoned globally as it allows educators to deliver quality instruction to remote learners, respond to the diverse learning styles of different audiences, address the paces and modalities, break down geographical barriers, and reduce emotional discomfort that non-traditional learners are prone to experiencing. Despite these advantages, online learners have experienced obstacles such as loss of concentration and motivation, distraction, time management difficulties, etc. As such, educational leaders utilize the assumptions of andragogy to address the unique contextual obstacles of online learning. This study helps course facilitators, curriculum developers, and instructional designers to delve into the Andragogical principles and their practical applications in online technical training programs.

Second, this study may inspire educational practitioners with new insight into integrating instructional initiatives grounded in multimedia. With the ubiquity of technology, multimedia learning, such as videos, slide decks, wiki pages, blogs, eLearnings, etc, has been integrated into

almost every learning program. Advances in multimedia technologies have inspired new efforts to leverage the potential of multimedia instruction as a means of promoting human learning, especially in a complex subject domain (i.e., technology learning). This study reviewed the principles of multimedia learning that allow educational practitioners to take an evidence-based approach to leverage learning results using well-designed multimedia instruction. This study revealed that using videos, mind maps, and simulations as multimedia-based instructional initiatives helps to enhance learners' learning outcomes and motivations. The mind map example and simulation examples are provided in Appendix F and Appendix G respectively. Thus, this study may inspire educators to design meaningful multimedia instruction in a learner-centered approach, which is aligned with how the human mind works and how humans process information.

Third, this study informs educators of a theory-grounded framework to design effective online technical capability-building solutions that are centered on the needs of learners. The researcher believes a training solution should work with students' schedules, engage students, develop the in-demand skill to solve real-world problems and prepare students for their future roles. For these reasons, the researcher streamlined a four-phase design framework in Chapter 3 that helps course facilitators and instructional designers to transform the course content into an effective and motivating self-paced learning experience step-by-step. The framework was provided in Appendix H - Framework of Instructional Design. This framework, centered on why and how humans learn, can help educational practitioners to outline the process that should be taken to develop sound instructional materials and activities.

Forth, the proposed approach of integrating the combined method of Andragogy and CTML in this study provides learners with a one-stop learning experience for them to learn and play the target skill in a flexible, safe, and effective learning setting. Learning programs grounded

in Andragogy in higher education settings have a significant impact on supporting students' professional goals, reducing learners' anxiety in the application of the subject matter, and facilitating self-directed learning. Multimedia provides a learning environment powered by multiple formats, such as image, text, video, animation, and audio presentation (Moos and Marroquin 2010). Compared with media that only uses a single information processing channel (auditory or visual), the usage of multimedia can improve learning (e.g., Mayer, 2008; Rolfe and Gray, 2011; Noetel et al., 2021). This can particularly benefit learners with low prior knowledge of a topic, and it suits well for the teaching of complex materials at a faster speed (Lucas and Abd Rahim, 2017). As a widely accepted and practiced approach, CTML principles can be effective guidelines that can be used for a specific learner group such as young adults through its combination with the adult learning theory of Andragogy.

Last, the study provides institutions with effective training strategies that are transferable, economical, reusable, and scalable. Applications and technology platforms are among the most significant enablers for just-in-time learning. Examples include next-generation learning management systems, virtual classrooms, polling software, instructional video applications, online assessment platforms, etc. The proposed online training approach for Excel can be a robust transferable strategy to other applications and platform training. The proposed learning initiatives used in this study (i.e., micro videos, simulations, and mind-maps) can be transferable to other technical training programs, too. This self-paced training strategy breaks the geographical restrictions and makes it easy to scale up among students, faculty, staff, and other stakeholders in an institution.

### **Recommendations**

The advent of computer technology and the decrease in the cost of technology have burgeoned digital adoption in both the educational sector and the corporates. Technical Training and Development (T&D) programs in higher education enable students to develop digital literacy that helps them to adapt to the modern educational system and the 21st-century workforce. This study found that the combined method of Andragogy and CTML can significantly improve students' learning outcomes and learning motivation in the T & D program. The researcher made the following seven suggestions for future research and two suggestions for future practices.

### **Recommendations for Future Research**

First, future researchers can replicate the instructional design and implement the study in different subject matters. This study formulated an evidence-based framework to design effective online technical capability-building solutions that are centered on the needs of learners. The researcher streamlined a four-phase design framework in Chapter 3 that can help course facilitators and instructional designers to transform the course content into an effective and motivating self-paced learning experience step-by-step. Implementing the study in other subject matter, such as learning management system training or data analysis tool training, may yield different results.

Second, future researchers can replicate the study with different participants. The participants in this study were students enrolled in academic degree programs in a religiously affiliated university on the West coast of the US. It is suggested that future study conducts the research with participants from different universities. Additionally, participants in this study were students from the five schools that are affiliated with the university: College of Arts and Sciences, School of Law, School of Management, School of Education, and School of Nursing and Health Professions. Conducting the study with participants from different educational majors may yield different results.



Third, it is suggested that future studies scale up this experiment in a larger group and utilize other data analysis methods as well. Due to the limited resource, the researcher only obtained learning data from a convenient sample of 44 students. Thus, the researcher utilized the two-sample one-tailed T-test to analyze the mean difference between the two groups. However, future researchers can scale up this experiment to obtain learning data from a larger sample size, based on which ANOVA can be employed to investigate the efficiency of the interventional strategy among participants with different levels of education, gender, ethnicity, major, etc. Moreover, a larger sample population can improve the validity of the statistical results.

Fourth, future studies can utilize different assessment instruments to measure learning outcomes. Multiple-choice questions designed to assess learning comprehension and skill transfer were used to measure the learning outcomes in this study. Other measuring instruments, such as task-based projects with clear rubrics, can be another valid assessment option that helps to determine the instructional effectiveness of the proposed method.

Fifth, the researcher suggests future scholars delve into students' learning outcomes and analyze the effectiveness of the proposed method in improving their knowledge comprehension and skill transfer. Mayer (2020, p. 239) claims that learning outcomes can be assessed through learners' knowledge comprehension and skill transfer. Because of the technological restriction of the school, the learners' learning outcomes in comprehension and skill transfer were not analyzed in this study. However, future researchers can carry on this research to further investigate the effectiveness of the proposed method in improving knowledge comprehension and still transfer.

Sixth, it is suggested that future research investigate the challenges and obstacles learners may encounter during the self-paced learning experience based on the proposed approach. The goal of determining the effectiveness of the proposed method is to develop students' digital

literacy. A deeper understanding of learners' challenges will yield informative insight for educators to design, deliver, and administrate self-paced technical training programs.

Seventh, the researcher suggests future scholars conduct this research in younger learners of K-12 education. Due to the COVID-19 pandemic, synchronized eLearning has gained increasing popularity in not only higher education but also K-12 sectors. An effective instructional approach that primes active cognitive processing during learning and leads to superior learning outcomes in higher education may benefit K-12 learners in various dimensions. Evidence-based research integrating the combined Andragogy and CTML method will yield informative insight that drives the pedagogical revolution.

### **Recommendations for Future Practice**

As educators, it is our responsibility to develop students the skills and knowledge that they need to succeed in the new era driven increasingly by technology. Despite the effectiveness of the combined method of Andragogy and CTML in maximizing learning outcomes and learning motivation in the self-paced T & D programs there are two recommendations to consider to ensure the successful implementation of this innovation.

First, educational leaders need to enable systems and learning-technology applications that meet the needs of instructional development and learning management. The rapid emergence of cloud-based learning technology provides educators unlimited opportunities to plug and unplug systems and access the latest technology without going through lengthy and expensive implementation processes (Dam, 2018, p. 28). Assessing the utilization and premises of equipment is an essential part of enabling the combined andragogical and CTML methodology in self-paced eLearning. A further step in the enabling processes involves the proper maintenance of the applications in the institution. If the systems are properly maintained and can produce useful

reports, the eLearning program would yield insightful learning analytics for program evaluation and evolution.

Second, before leaders develop a culture of integrating the Andragogy and CTML approach or implementing cutting-edge teaching technologies, they must look inward at their own structure and governance and develop a stable yet flexible process for designing the self-paced learning programs. The governance and process define resources, responsibilities, scope, milestones, and tasks among stakeholders and help to align and engage them throughout the strategic planning and execution. Internal networks or sub-teams residing in the institution enable the instructors to connect the teaching agenda to the technological specialists who support the teaching innovation initiatives. These processes of designing the Andragogy and CTML-enhanced eLearning require time and financial investment, and the implementation of the eLearning program entails some risk, and perhaps some trial and error, but the rewards will be great in the long run because of economies of scale-up and re-use.

### **Closing Remarks**

This study revealed a noticeable effect of the combined method of Andragogy and CTML in improving learning outcomes and motivation. Adult learning principles “work best in practice when adapted to fit the uniqueness of the learners and the learning situation” (Knowles et al., 2015, p. 17). Their strength is that these core principles apply to all adult learning situations, as long as they are considered in concert with other factors that are present in the situation. Thus, the researcher strategically integrated it with Mayer’s (2003, 2020) cognitive theory of multimedia learning. Mayer (2020) indicates that multimedia learning off-loads cognitive processing and facilitates knowledge construction and thus leading to better learning outcomes and experiences. Thus, the researcher exploited both Andragogy and CTML to shape the design, development, and

evolution of self-paced online learning. Incorporating these principles enabled the learners to eliminate this extraneous processing and thus make the best use of the limited processing capacity to process the information relevant to the instructional goals, thus facilitating learning motivation and learning outcomes.

This study informs educators of a theory-grounded framework to design effective online technical capability-building solutions that are centered on the needs of learners. Further, this study may help educational practitioners to effectively utilize the Andragogical principles to address the unique contextual obstacles of young adult learners in online learning settings. Moreover, this study may also inspire educational practitioners with new insight into integrating instructional initiatives grounded in multimedia. The proposed approach of integrating the combined method of Andragogy and CTML in this study provides learners with a one-stop learning experience for them to learn and play the target skill in a flexible, safe, and effective learning setting.

To promote the effective method of Andragogy and CTML, the researcher streamlined the four-phase design framework in Chapter 3 that helps course facilitators and instructional designers to transform the course content into an effective and motivating self-paced learning experience step-by-step. The framework was provided in Appendix H - Framework of Instructional Design. This framework, centered on why and how humans learn, helps educational practitioners to outline the process that should be taken to develop instructionally sound materials and activities. The researcher hopes new methodologies will be investigated and more instructionally sound T & D programs will be established to enable our students to thrive in the digitized world.

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## **Appendices**


**APPENDIX A**  
**IRB APPROAVAL**

Expedited Review Approved by Chair - IRB ID: 1813

INBOX

Important

Notification



Richard Gregory Johnson III


To: [rgao15@usfca.edu](mailto:rgao15@usfca.edu)

Sunday, Oct 2, 9:03 PM

↩ ⋮

Downloadable Attachments:

[Expedited Review Approved by Chair - IRB ID: 1813.pdf](#)



UNIVERSITY OF  
SAN FRANCISCO

IRBPHS - Approval Notification

To: Shanhua Gao

From: Richard Gregory Johnson III, IRB Chair

Subject: Protocol #1813

Date: 10/02/2022

The Institutional Review Board for the Protection of Human Subjects (IRBPHS) at the University of San Francisco (USF) has reviewed your request for human subjects approval regarding your study. Your research (IRB Protocol #1813) with the project title **THE EFFECTIVENESS OF A COMBINED METHOD OF ANDRAGOGY AND COGNITIVE THEORY OF MULTIMEDIA LEARNING IN SELF-PACED TRAINING AND DEVELOPMENT PROGRAMS IN HIGHER EDUCATION** has been approved by the IRB Chair under the rules for expedited review on 10/02/2022.

Any modifications, adverse reactions or complications must be reported using a modification application to the IRBPHS within ten (10) working days.

If you have any questions, please contact the IRBPHS via email at [IRBPHS@usfca.edu](mailto:IRBPHS@usfca.edu). Please include the Protocol number assigned to your application in your correspondence.

On behalf of the IRBPHS committee, I wish you much success in your research.

Sincerely,  
Dr. Richard Gregory Johnson III  
Professor & Chair, Institutional Review Board for the Protection of Human Subjects  
University of San Francisco  
[rgao15@usfca.edu](mailto:rgao15@usfca.edu)  
[IRBPHS Website](#)



**APPENDIX B**  
**EMAIL OF CONSENT**



John Bansavich  
To: Shanshan Gao

Thursday, Sep 1, 6:29 PM

Hi Shanshan:

Please let me know if this will do:

[08/31/2022]

Institutional Review Board for the Protection of Human Subjects  
University of San Francisco  
2130 Fulton Street  
San Francisco, CA 94117

Dear Members of the Committee,

On behalf of the University of San Francisco's Instructional Technology Training department, I am writing this letter to confirm our consent to have Miss. Shanshan Gao conduct a research study, pending IRBPHS approval. The consent is for a research study being performed at the Mastering Excel for Real World training to meet the needs of the study during the 2022-2023 school year.

If you have questions or concerns, please feel free to contact me at (415)-422-5529.

Sincerely,

Dr. John Bansavich  
Director of the Instructional Technology Training (ITT)

--

John Bansavich, Ed.D.  
Director, Instructional Technology and Training  
University of San Francisco  
415-422-5529  
bansavich@usfca.edu  
<http://ets.usfca.edu>

**APPENDIX C**

**CONSENT FORM FOR RESEARCH PARTICIPATION**

**Study Title:**

The Effectiveness of a Combined Method of Andragogy and Cognitive Theory of Multimedia Learning in Self-Paced Training and Development Programs in Higher Education

**Consent to Participant in a Research Study**

Below is a description of the research procedures and an explanation of your rights as a research participant. Please read this information carefully. If you agree to participate, you will sign in the space provided to indicate that you have read and understand the information on this consent form.

You have been asked to participate in a research study conducted by Shanshan Gao, a doctoral student in the Learning and Instruction program at the University of San Francisco. Your learning data will be protected and anonymous.

**Purpose of the Study:**

The purpose of this study is to investigate the effectiveness of the combined method of Andragogy and cognitive load of multimedia learning (CTML) in (1) enhancing learning results in T& D programs in higher education; and (2) optimizing students' learning experience regarding learning motivation, autonomy, and satisfaction.

**What We will Ask You to Do:**

If you accept to be a participant in this study, you will be registered for the self-paced training - Mastering Excel for Real World - on Canvas. This training will take about 50 to 60 minutes and you will have 10 days to complete the training.

When you start the learning journey, you will be prompted to sign the consent form which indicates your participation in this research. You fill out the demographic information form

including your age, gender, school of education, level of education, and ethnicity. Then, you will learn excel through self-paced eLearning. You will need to participate in a pre-test consisting of 15 multiple-choice questions. At the end of each module, you will be prompted to take a post-test. Before exiting the eLearning experience, you will be asked to fill out a survey to share your opinions about the course. The survey will take two to three minutes to complete.

You will also be asked to indicate your preference and availability for a 30-minute Zoom interview for the following week. The researcher will conduct a focus group interview to seek your opinions and get a sense of your experience learning in this program. The interviews will be recorded for the purpose of transcription and data analysis. A pseudonym will be assigned to you to protect your information and the recording will be deleted forever after this research.

**Study Time:**

The training will take 50 to 60 minutes to complete. It will take an extra 30 minutes if you volunteer to take the follow-up Zoom interview.

**Study Location:**

This is an asynchronous training, and you will be able to undertake the learning anywhere at your convince.

**Potential Risks and Discomforts:**

We do not anticipate any risks or discomforts to you from participating in this research. If you wish, you may choose to withdraw your consent and discontinue your participation at any time during the study without penalty.

**Benefits:**

1. Participants will master technical skills in Excel.

2. Participants will receive a verified digital badge that certifies their Excel skills.
3. Participants will receive a \$20 Amazon gift card on a random drawing.
4. Participants will receive a \$ 20 Amazon gift card if they participate a 30-minute remote interview.

**Privacy/Confidentiality:**

You will not be providing any information that can uniquely identify you (such as your name or student ID number). The data you provide will be anonymous.

**Payment for Participation:**

You will not be paid for participating in this study.

**Voluntary Nature of the Study:**

Your participation is voluntary, and you may refuse to participate without penalty. You may skip any questions or tasks that make you uncomfortable and may discontinue your participation at any time without penalty. In addition, the researcher has the right to withdraw you from participation in the study at any time.

**Offer to Answer Question:**

If you have questions later, please contact the researcher (Shanshan Gao) at (415) - 990-7882) or (sgao15@dons.usfca.edu). If you have questions or concerns about your rights as a participant in this study, you may contact the University of San Francisco Institutional Review Board at IRBPHS@usfca.edu.

**Consent:**

I HAVE READ THE ABOVE INFORMATION. ANY QUESTIONS I HAVE ASKED HAVE BEEN ANSWERED. I AGREE TO PARTICIPATE IN THIS RESEARCH PROJECT AND I WILL RECEIVE A COPY OF THIS CONSENT FORM.

---

Participant's Signature

Date

**APPENDIX D**  
**ADOBE SPARK PAGE**





The Instructional Technologies and Training (ITT) department is launching a self-paced eLearning for Excel to support doctoral dissertation research in the School of Education.



This self-paced learning will be counted as 1/7 of courses of the Data Analysis Proficient badge programs, which means you will be exempted to take Excel Basics training in order to earn the Data Analysis Proficient badge! Sign up for the training by logging your Person of Contact [in the spreadsheet](#)



As an incentive to participate, learners may receive \$20 Amazon gift card on a random drawing and will receive \$20 Amazon gift card on participation of a 30-minute remote interview.

Please email me to sign up the training @ [sgaot15@dons.usfca.edu](mailto:sgaot15@dons.usfca.edu)

## STUDY TIME

The training will take 50 to 60 minutes to complete. It will take an extra 30 minutes if you volunteer to take the follow-up Zoom interview.





#### Study Title:

The Effectiveness of a Combined Method of Andragogy and Cognitive Theory of Multimedia Learning in Self-Paced Training and Development Programs in Higher Education

#### Purpose of the Study:

The purpose of this study is to investigate the effectiveness of the combined method of Andragogy and cognitive load of multimedia learning (CTML) in (1) enhancing learning results in T&D programs in higher education; and (2) optimizing students' learning experience regarding learning motivation, autonomy, and satisfaction.

#### What We will Ask You to Do:

If you accept to be a participant in this study, you will be registered for the self-paced training - Mastering Excel for Real World - on Canvas. This training will take about 50 to 60 minutes and you will have 10 days to complete the training.

You will be learning Excel fundamentals through videos, simulations, and quizzes that help you to reinforce what you've learned. At the end of the training, you will also be asked to indicate your preference for an optional 30-minute Zoom interview to learn more about your learning experience. As an appreciation of your interview participation, the researcher will offer you a \$20 Amazon Gift card.

#### Study Time:

The training will take 50 to 60 minutes to complete. It will take an extra 30 minutes if you volunteer to take the follow-up Zoom interview.

#### Study Location:

This is an asynchronous training, and you will be able to undertake the learning anywhere at your convenience.

#### Potential Risks and Discomforts:

We do not anticipate any risks or discomforts to you from participating in this research. If you wish, you may choose to withdraw your consent and discontinue your participation at any time during the study without penalty.

#### Benefits:

1. Participants will master fundamental skills in Excel.
2. Participants will receive a \$20 Amazon gift card on a random drawing.
3. Participants will receive a \$20 Amazon gift card if they participate a 30-minute remote interview.

#### Privacy/Confidentiality:

You will not be providing any information that can uniquely identify you (such as your name or student ID number). The data you provide will be anonymous.

#### Payment for Participation:

You will not be paid for participating in this study.

Sign up for the training by logging your Person of Contact in [this spreadsheet](#)

Please email me @ [sgaot5@dons.usfca.edu](mailto:sgaot5@dons.usfca.edu) if you have any questions.



**APPENDIX E**  
**PRE-/POST-TEST**

## Module 1:

1. Excel is \_\_\_\_\_.
  - a. a computer program for free-form information gathering and cloud-based collaboration.
  - b. a slideshow presentation program used for delivering presentations to audiences.
  - c. a word processing program used for creating documents and text-based projects.
  - d. an electronic spreadsheet program used for storing, organizing, and manipulating data.
2. Which statement regarding workbook and worksheet is correct? Select all that apply.
  - a. A worksheet is a file, and a workbook is an individual tab within the worksheet.
  - b. The Worksheet is a single-page spreadsheet, and a workbook is just a file or a book.
  - c. The worksheet consists of a matrix of rectangular cells, organized in a tabular form of rows and columns.
  - d. The workbook consists of one or more worksheets, having various sorts of related information.
  - e. Many workbooks can be used at the same time in a worksheet and many sets of data can be used at the same time in a workbook.
3. What will happen if you copy the formula of cell E11 to cell F11?

	A	B	C	D	E	F	G	H
1	Activities - Week of 6/6	Monday 6/6/22	Tuesday 6/7/22	Wednesday 6/8/22	Thursday 6/9/22	Friday 6/10/22	Saturday 6/11/22	Sunday 6/12/22
2								
3	Continuing learning - Voyond	1	0	0	1.5	1.5		
4	Continuing learning - Storyline	1	2	1.5	0	0		
5	Meetings	1.5	1	1.5	1	1		
6	Privacy Academy Project	3	3.5	3	0.5	0.5		
7	ROAR Project	0.5	0.5	1	3.5	3.5		
8	Messages & emails	1	1	1	1.5	1.5		
9								
10								
11	Total (daily)	8	8	8	8			
12	Total (week)	32						

- a. Excel will copy the number of E 11 to F 11.
- b. Excel will carry over the formula but you need to re-adjust 5 cells (cell E 3 to cell E 8).

- c. Excel will carry over the formula and the cells being involved (Cell E 3 and E 8).

Excel will carry over the formula and adjust the corresponding cells accordingly to reflect the new set of cells being involved.

4. The most efficient way to add up five different cells in a column is to type the equal sign into the formula bar and then:

- a. Use arrow keys to select the cells, and type a plus sign in between each.
- b. Type each cell location and type a plus sign in between each.
- c. Hit the equal sign to use the SUM function and click on each cell and type a plus sign in between each.
- d. Hit the equal sign to use the SUM function, type an open parenthesis, and then highlight the five cells.

5. You are entering Sales data for each month in 2022. How can you quickly enter all 12 months in columns?

- a. Type in "January," point to the lower right-hand corner of the cell, hold down the right mouse button, and drag across the next 11 rows.
- b. Type in "January," left-click the January cell, type "EXTEND," and the other 11 months will be filled in.
- c. Type in "January," left-click for the Shortcut menu, select Copy, move your mouse over the next 11 cells, and then click Paste.
- d. Type in "January," point to the lower right-hand corner of the cell, hold down the left mouse button, and drag across the next 11 rows.

## **Module 2:**

- 7. What is the best practice for entering dates and times in Excel?

- a. Use slashes for dates and colons for time.
  - b. Use slashes for dates and periods for time.
  - c. Use dashes for dates and colons for time.
  - d. Use periods for dates and colons for time.
8. If you right-click on a row reference number and click on Insert, where will the row be added?
- a. Above the row you selected.
  - b. Below the row you selected.
  - c. At the bottom of the worksheet.
  - d. At the top of the worksheet.
9. What should be done to solve the problem in cell C2?

	A	B	C	D	E
1	Title	Worldwide	Domestic	Overseas	Year
2	Avatar	2,788.00	#####	2,027.50	2009
3	Titanic	2,175.50	659.40	1,528.10	1997
4	Star Wars:	2,068.20	936.70	1,131.60	2015
5	Jurassic W	1,671.70	652.30	1,019.40	2015
6	Marvel's T	1,518.80	623.40	895.50	2012
7	Furious 7	1,516.80	353.00	1,163.00	2015
8	Avengers:	1,405.40	459.00	946.40	2015
9	Harry Port	1,341.50	381.00	960.50	2011
10	Star Wars:	1,331.90	619.70	712.20	2017
11	Frozen	1,276.50	400.70	875.70	2013

- a. Change the number format
- b. Type the number again
- c. Enlarge the space
- d. Cannot be determined

10. To free rows 1 and 2, and columns 1, 2, and 3, which cell should you highlight before selecting Freeze Panes?

- a. Row 3, column 4
- b. Row 1, column 3
- c. Row 3, column 1
- d. Row 2, column 3

11. In the data shown below, if you want to move the Worldwide after the Overseas, what is the fastest way to move this data?

	A	B	C	D	E
1	Title	Worldwide	Domestic	Overseas	Year
2	Avatar	2,788.00	760.50	2,027.50	2009
3	Titanic	2,175.50	659.40	1,528.10	1997
4	Star Wars:	2,068.20	936.70	1,131.60	2015
5	Jurassic W	1,671.70	652.30	1,019.40	2015
6	Marvel's T	1,518.80	623.40	895.50	2012
7	Furious 7	1,516.80	353.00	1,163.00	2015
8	Avengers:	1,405.40	459.00	946.40	2015
9	Harry Port	1,341.50	381.00	960.50	2011
10	Star Wars:	1,331.90	619.70	712.20	2017
11	Frozen	1,276.50	400.70	875.70	2013

- a. Click B to highlight the column and then left-click and hold to drag the data after the Overseas column.
- b. Click B to highlight the column and then hold the Shift key down and drag the column after the Overseas column.
- c. Click D and right-click to insert a column. Then click B and right-click and select Cut then Paste the data into the new column.
- d. Click B to highlight the column then hold the Ctrl key down and drag the column after the Overseas column.

### Module 3:

12. What is the first step in creating a chart?

- a. Create totals for each row and each column.
- b. Insert a row of empty cells beneath the title.
- c. Highlight the data you want to show in the chart.
- d. Select the chart type you are interested in showing.

13. Which one below will prevent the appearance of a chart?

- a. Row headings
- b. Column headings
- c. Zero values
- d. Totals next to the data

14. In the image below, which cells will you use to create a chart to represent the top movies worldwide, domestic, and overseas grossing data?

	A	B	C	D	E	F
1	Top Movies Grossing					
2	Rank	Title	Worldwide	Domestic	Overseas	Year
3	1	Avatar	2,788.00	760.50	2,027.50	2009
4	2	Titanic	2,175.50	659.40	1,528.10	1997
5	3	Star Wars:	2,068.20	936.70	1,131.60	2015
6	4	Jurassic W	1,671.70	652.30	1,019.40	2015
7	5	Marvel's T	1,518.80	623.40	895.50	2012
8	6	Furious 7	1,516.80	353.00	1,163.00	2015
9	7	Avengers:	1,405.40	459.00	946.40	2015
10	8	Harry Port	1,341.50	381.00	960.50	2011
11	9	Star Wars:	1,331.90	619.70	712.20	2017
12	10	Frozen	1,276.50	400.70	875.70	2013

- a. A1:F12
- b. B3:E12
- c. A2:F12



d. B2:E12

15. Which type of chart would best illustrate the data above?

- a. Pie
- b. Line
- c. Bar
- d. Area

**APPENDIX F**  
**SURVEY**

This survey is to evaluate how this training was designed to meet your learning needs of you. It will take two to 3 minutes to complete. Please answer sincerely.

Thank you for answering these questions:

1. I enjoyed the learning materials in this course.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

2. This self-paced eLearning encouraged me to continue learning on the Internet by myself.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

3. Generally, I was happy and satisfied with the self-paced Excel Training.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

4. I believed the self-paced eLearning will be beneficial to me.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

5. I had a clear idea of what was expected to learn and what was expected from me.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

6. I think my time spent in this training is worth well.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

7. I became a more active learner in the self-paced Excel Training, compared to my usual classes.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree

- ☐ Strongly disagree

8. I took my own responsibility for my learning in this course.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

9. I think self-paced eLearning improved my basic understanding and skills in Excel.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

10. Participating in this training is obligatory because I may need the Excel skills later (for job, study, etc).

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

11. I had the freedom to participate in the course at my own pace and convenience.

- ☐ Strongly agree
- ☐ Agree

- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

12. I think the self-paced Excel training equipped me with basic skills to fulfill school assignments.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

13. Learning in this course will help me organize data in my daily life, for example my monthly expenses, track my time spent each week, etc.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

14. Learning in this self-paced course stimulated my interest for further learning.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

15. I think self-paced Excel training equipped me with basic skills that are needed for most jobs in the real world.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neither agree nor disagree
- ☐ Disagree
- ☐ Strongly disagree

**APPENDIX G**  
**GROUP INTERVIEW QUESTIONS**



1. How was this training beneficial to you?
2. What captured your learning interests in the training?
3. What aspects of this course are helping you learn? Can you give me some examples.
4. What do you wish to be changed in the course?
5. How might Excel training benefit you?
6. What difficulties and barriers have you encountered during this training?

Note: The researcher may ask additional follow-up questions, as appropriate, with participants.

**APPENDIX H**

**FRAMEWORK OF INSTRUCTIONAL DESIGN**

---

**Step 1: Savvy start**

---

Step 1.1 Craft an actionable, results-oriented, and contextualized title.

---

Step 1.2 Describe the course clearly: Inform the learners about what they will learn.

---

Step 1.3 Address course goals and objectives: Explain what competency learners will obtain as a result of this learning.

---

Step 1.4 Inform the benefits of learning the target skills and the negative consequences of not learning them.

---

Step 1.5 Inform the practical relevance of the target skills to real life.

---

Step 1.6 Make human connections: Introduce yourself, your role at the institution and your experience in the subject matter.

---

---

**Step 2: Content Development**

---

Step 2.1 Segment: Organize and present information in smaller steps or chunks based on key concepts to reduce the cognitive load of working memory.

---

Step 2.2 Eliminate extraneous information that doesn't align with learning objectives.

---

Step 2.3 Introduce the names and characteristics of the main concepts before diving into the content presentation.

---

Step 2.4 Provided preliminary resources for the course.

---

Step 2.5 Present content with multimedia materials. E.g.: videos, mind maps, simulated activities, etc.

---

Step 2.6 Contextualize targeted skills by showing the practical use cases.

---

Step 2.7 Connect targeted skills with additional real-world applications/examples.

---

Step 2.8 Maintain conversational style rather than formal style.

---

---

Step 2.9 Record a friendly human voice with enthusiasm for narrations rather than using a machine voice.

---

Step 2.10 Use reflective questions to facilitate knowledge re-construction. E.g.: What is the difference between two concepts? What is your biggest takeaway from this class?

---

Step 2.11 Provide hands on-practice activity to facilitate knowledge retention.

---

### **Step 3: Content Closure**

---

Step 3.1 Recap the key concepts.

---

Step 3.2 Elicit emotion and a sense of achievement.

Highlight knowledge competency learners developed - Align with learning goals.

---

Step 3.3 Provide instructional support/additional resources as needed.

---

Guideline 3.4 Call to action.

---

### **Step 4: Learning Experience Design**

---

Step 4.1 Maintain coherence: Design a coherent format throughout the learning experience, including the coherent structure of each learning module, the coherent design style of the videos, mind maps, and simulations.

---

Step 4.2 Maintain spatial contiguity: Present related words and pictures spatially close to one another; Synchronize words or narration with graphics.

---

Step 4.3 Maintain temporal contiguity: Present corresponding narration and images/animations simultaneously.

---

Step 4.4 Add visual and audio cues that guide learners' attention to the relevant elements of the material.

---

Step 4.5 De-redundancy: Remove any irrelevant information from multimedia. E.g.: animation, extra frame of a screencast video, music, etc.

---



**APPENDIX I**  
**ELEARNING SCOPE**

## Module 1: Getting Started

- a. Creating a workbook
- b. Modifying worksheet
- c. Performing basic formulas

## Module 2:

- a. Formatting dates & time
- b. Working with rows & columns
- c. Freezing panes

## Module 3: Creating and modifying charts

- a. Creating charts
- b. Modifying charts

**APPENDIX J**

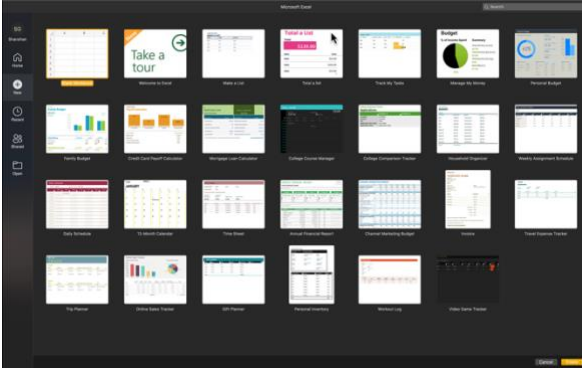
**STORYBOARD FOR MICRO-VIDEO TUTORIALS**



## Storyboard 1.1: Creating a Workbook

### Visual

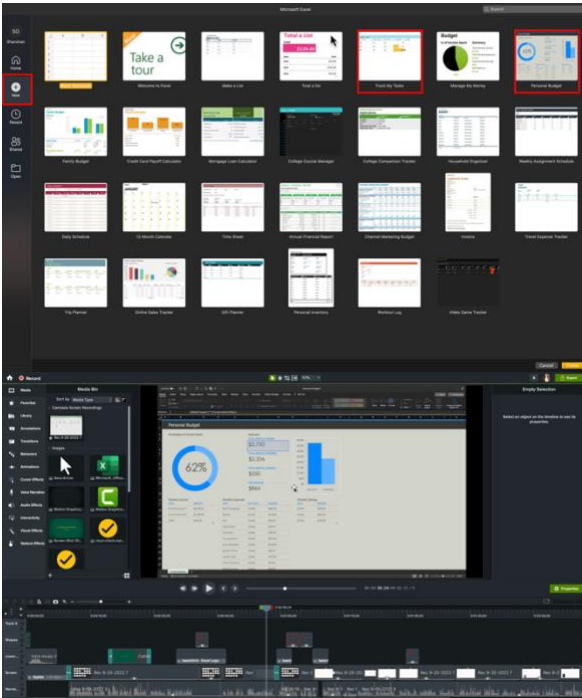
#### 1. Intro



### Narration

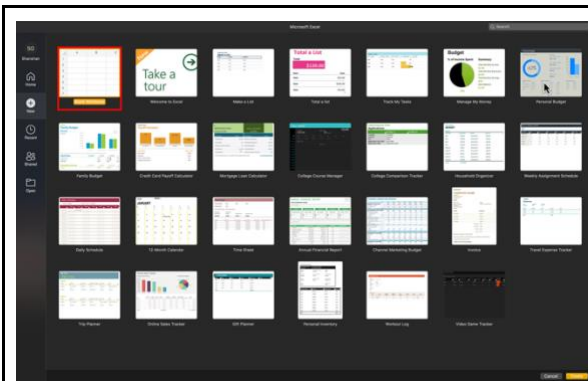
When you open excel, the very first thing you need to do is to create a workbook, which will help you to organize the data. In excel, a file is a workbook and a workbook is also called a file, so these two terms can be used interchangeably.

#### 2. Create a workbook



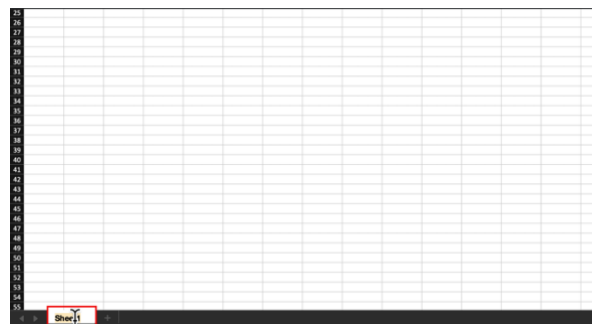
To create a workbook, you can start from a template, or start from scratch.

- If you want a head-start on a particular kind of workbook, under the New tab, you can see a collection of templates that work for various purposes, for example, track my tasks, personal budget, etc. Here you can select a template that works for your own purpose, and make any adjustments.

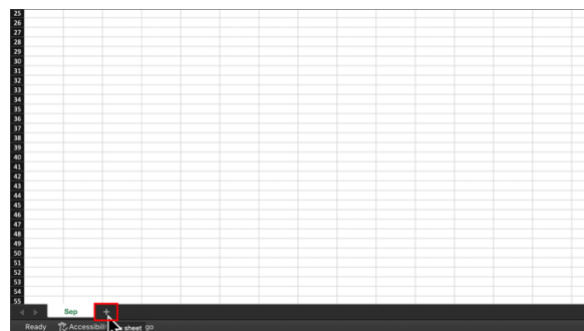


- If you want to start from scratch, just click **Blank Workbook**, and click **Create**. A blank workbook will open up.

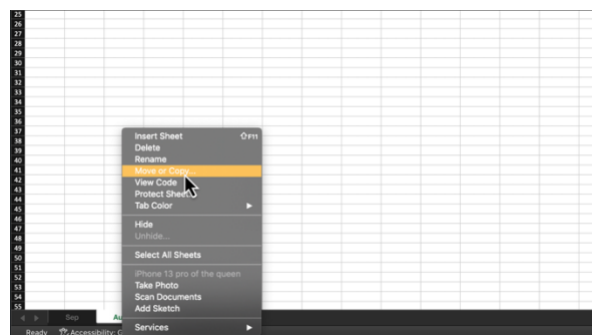
## 0. Interact with a worksheet



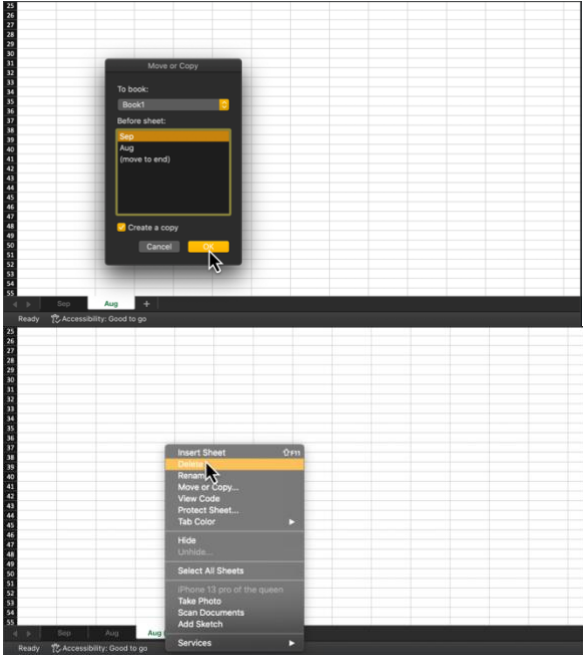

Inside the new workbook, we can have at least one worksheet. We can rename it by double clicking the name of the worksheet. I am gonna rename the first worksheet as “Sep” here. When I am done, just click the return on my keyboard to save the change.

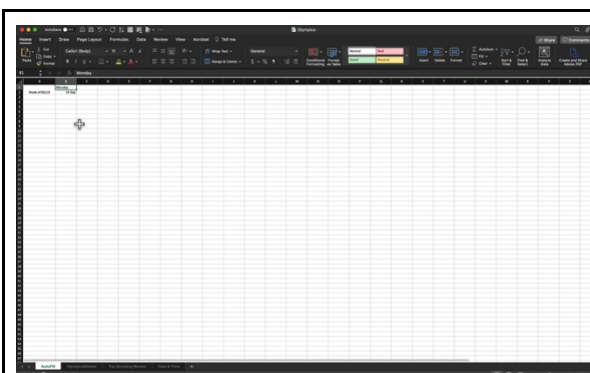


You can add a new worksheet simply by clicking the “+” button. You can create as many worksheets as you want and rename it. I am gonna rename the new worksheet to “Aug” here.

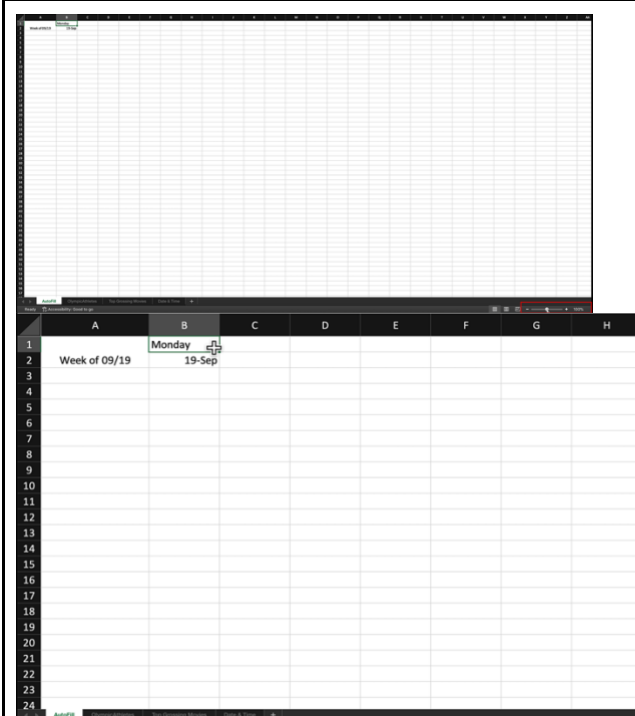


For each worksheet, we can copy, paste, delete, or even re-arrange it. To copy a worksheet, simply right click a worksheet, from the drop down menu, click “Move or

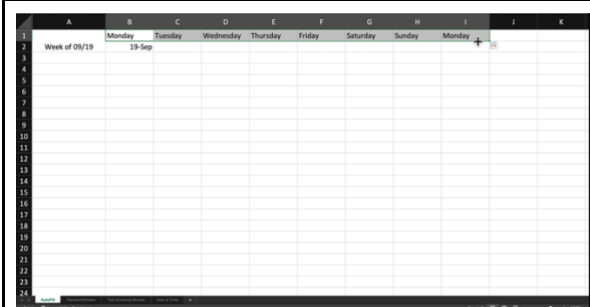
	<p>Copy”, select a worksheet, before which you want the new worksheet to be inserted. Then, toggle the create a copy button and click ok.</p> <p>To re-arrange a worksheet, just drag the worksheet to your preferred sequence. To delete a worksheet, just right click it, and select delete.</p>
	<p>So now you’ve learned how to</p> <ol style="list-style-type: none"> <li>1. create a workbook.</li> <li>2. Create multiple worksheets in a workbook</li> <li>3. Interact with worksheet (such as rename, copy, re-arrange, and delete a worksheet).</li> </ol>
<b>Storyboard 1.2: Entering Data</b>	
<b>Visual</b>	<b>Narration</b>



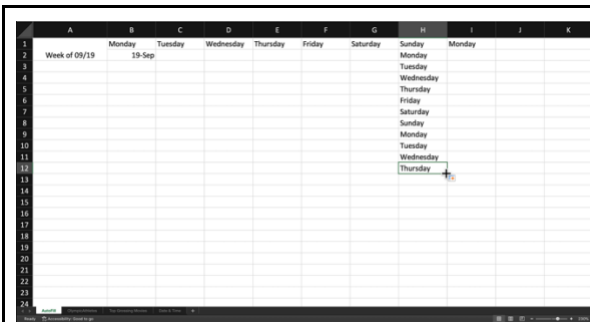
Sometimes you need to enter a lot of repetitive information in Excel, such as dates, months, and it can be really tedious. There is a feature called Auto fill that really helps to save your time!



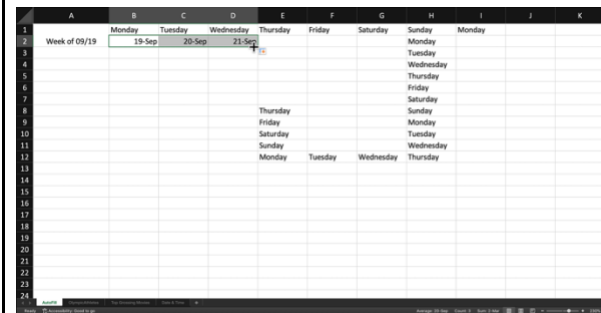
In the AutoFill worksheet, we're going to enter more weekdays and dates. But before doing that, there is a slider on the lower right corner that we should know. We can zoom in the worksheet by dragging the slider rightward. So it becomes easier for us to work on the worksheet.



Anytime you're going to enter data that follows a pattern, you can put the mouse pointer over the bottom right corner of the cell until it becomes a black and thinner plus sign. Holding the left mouse button and drag the plus sign over the cells you want to fill.



We can drag rightward all the way to Sunday and beyond, and it will start over again.



We can drag in other ways like downward, leftward, and upward. Same thing happens with dates.

### Storyboard 1.3: Performing Basic Calculations

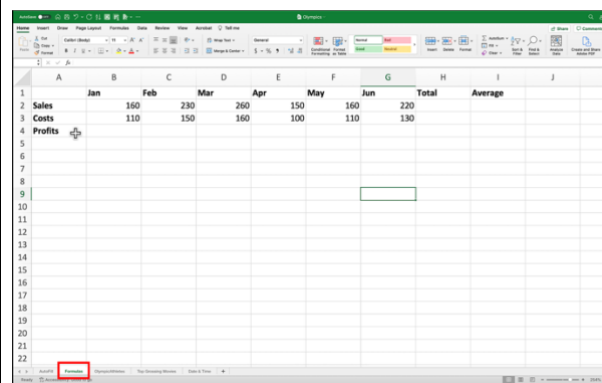
#### Visual

##### Intro



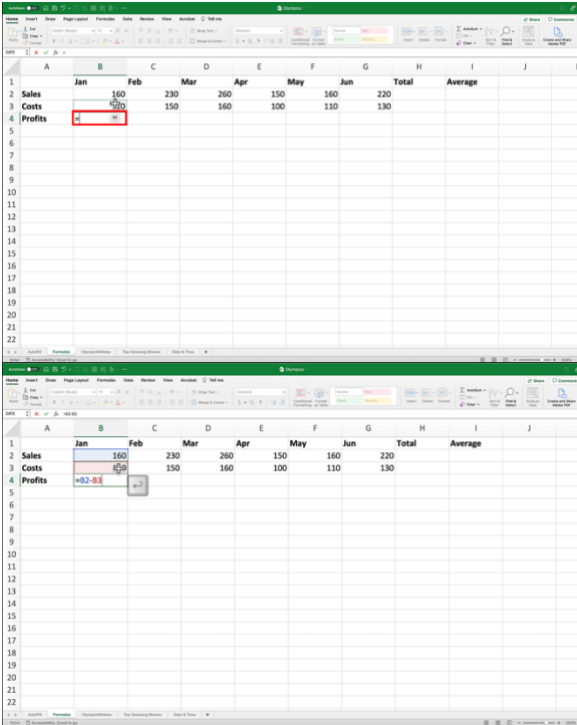
#### Narration

In the real world, oftentimes we need to perform calculations in order to solve problems. Instead of using a calculator, Excel can help you to do the math!



In the formulas worksheet of our exercise file, we want to calculate the profit of each month, the total and average of the sales, costs, and profits.

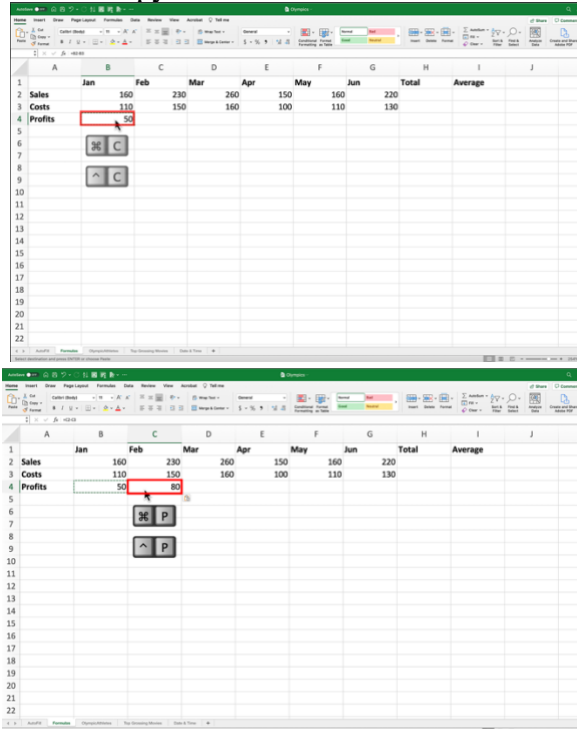
## 1. Subtraction



	Jan	Feb	Mar	Apr	May	Jun	Total	Average
1								
2	Sales	160	230	260	150	160	220	
3	Costs	110	150	160	100	110	130	
4	Profits	=B2-C3						

There might be different ways to create formulas, but they all start with the equal sign. In cell B4, I'll type the equal sign to start the formula, and select B2, type minus sign, and select C3, and hit the Return button on mac or Enter button on windows to complete the formula and get the answer. You've probably noticed the formula is also shown in the formula bar. It's highly recommended to keep an eye on the formula bar which helps to mitigate mistakes.

## 0. Copy formula



	Jan	Feb	Mar	Apr	May	Jun	Total	Average
1								
2	Sales	160	230	260	150	160	220	
3	Costs	110	150	160	100	110	130	
4	Profits	=B2-C3						

No matter how comfortable you're with creating the formulas, writing the same formula to calculate the profits one by one can be tedious and time-consuming. The good news is Excel allows us to copy the formula to another location. For example, we can simply copy the formula of B4 by hitting Command or Control C. And paste it into cell C4, by clicking Command or Control P. As you see, Excel did not copy the value, but carried over the relative formula, and

The first screenshot shows the following data:

	Jan	Feb	Mar	Apr	May	Jun	Total	Average
Sales	160	230	260	150	160	220		
Costs	110	150	160	100	110	130		
Profits	50	80						

The second screenshot shows the same data with the formula copied to other months:

	Jan	Feb	Mar	Apr	May	Jun	Total	Average
Sales	160	230	260	150	160	220		
Costs	110	150	160	100	110	130		
Profits	50	80	100	50	50	90		

gave us the correct result based on the cells in question.

Copy and paste formula can definitely get our calculation up to speed. But there is another way to copy the formulas that will make our process even leaner, which is the autofill function. In cell C4, I'll hover over the bottom right corner of the cell, until it becomes a black and thinner plus sign. I'll hold the left mouse button and drag it over to G4. So, we get the profits for other months as well.

## 0. Addition

The screenshot shows the following data:

	Jan	Feb	Mar	Apr	May	Jun	Total	Average
Sales	160	230	260	150	160	220	$=B2+C2+D2+E2+F2+G2$	
Costs	110	150	160	100	110	130		
Profits	50	80	100	50	50	90		

To calculate the total of the sales, we'll need to start with the equal sign in Cell H2. and select B2, type +, select C2, + D2, + E2, +F2, +G2, and hit Return button on mac or Enter button on windows to get the result. Although keeping an eye on the formula bar can minimize the chance of making mistakes, the process of writing this formula

	Jan	Feb	Mar	Apr	May	Jun	Total	Average
Sales	160	230	260	150	160	220	1180	
Costs	110	150	160	100	110	130		
Profits	50	80	100	50	50	90		

can be tedious. In this case, we can use the built-in function to perform the calculation.

## 0. Built in function-Sum

	Jan	Feb	Mar	Apr	May	Jun	Total	Average
Sales	160	230	260	150	160	220	1180	
Costs	110	150	160	100	110	130		
Profits	50	80	100	50	50	90		

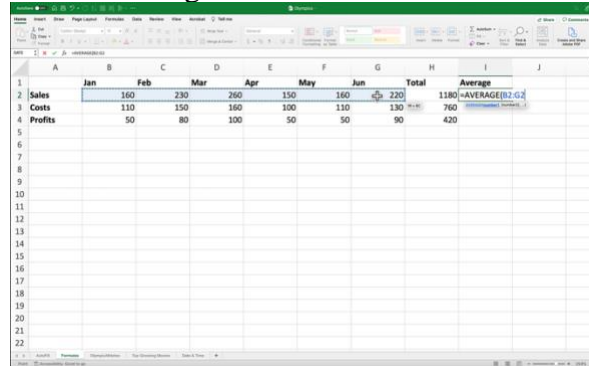
So, I'll delete the value of H2 and restart the calculation with the equal sign, and type sum, and choose the built-in sum function from the pop-up menu.

Here we can just select the cells in question, in our case B2 to G2, and hit the return Button on mac or Enter button on windows to get the result.

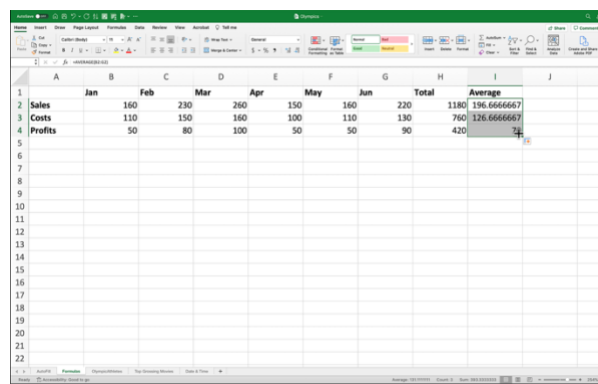
Here we can take the advantage of the auto fill again to calculate the total for costs and profits. So we hover over the bottom right of H2 until it becomes a thinner and black plus sign, and drag it over to H4. The relative calculations were carried over and we got the result.



## 0. Average



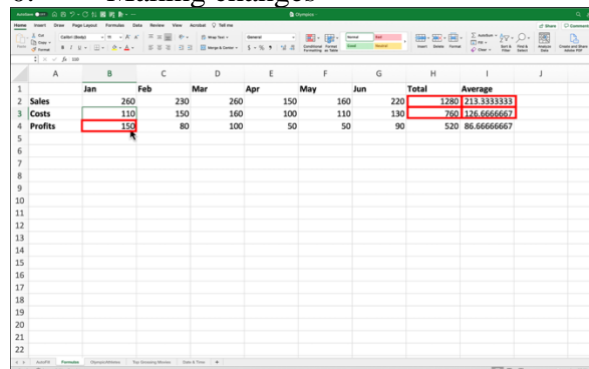
	Jan	Feb	Mar	Apr	May	Jun	Total	Average
Sales	160	230	260	150	160	220	1180	AVERAGE(B2:G2)
Costs	110	150	160	100	110	130	760	
Profits	50	80	100	50	50	90	420	



	Jan	Feb	Mar	Apr	May	Jun	Total	Average
Sales	160	230	260	150	160	220	1180	196.6666667
Costs	110	150	160	100	110	130	760	126.6666667
Profits	50	80	100	50	50	90	420	

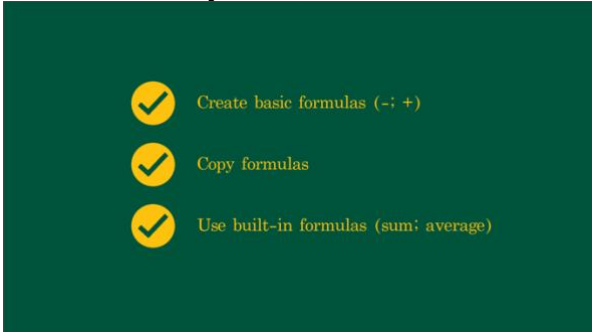


Similarly, to calculate the Average of the sales, we start with the equal sign, and type the initial of average and choose average function from the pop-up menu. Select the cells in question, in our case B2 to G2, and hit return on mac or enter on windows to get the result. And again, we can use the autofill to drag the relative function to cell I-3 and I4 to get the average for costs and profits.

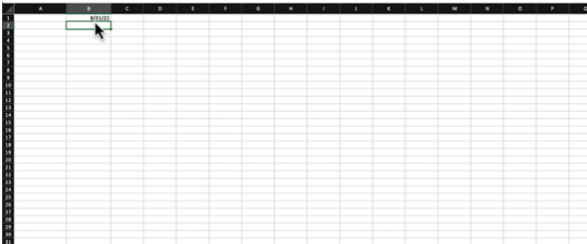
## 0. Making changes



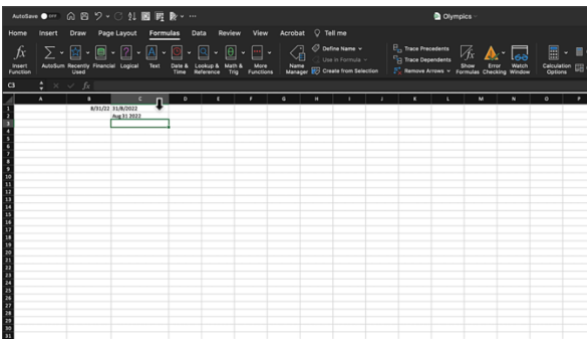
	Jan	Feb	Mar	Apr	May	Jun	Total	Average
Sales	260	230	260	150	160	220	1280	213.3333333
Costs	110	150	160	100	110	130	760	126.6666667
Profits	150	80	100	50	50	90	520	86.66666667

Later on, if you need to make any adjustment on your data, the formulas will respond accordingly. For example, if we change the sale of January to 260, notice that the value of B4, H2, H4, I2 I4 Fall the 5 cells have changed. which means if you made adjustment in a different time, all the formulas will act responsively to maintain the accurate result.

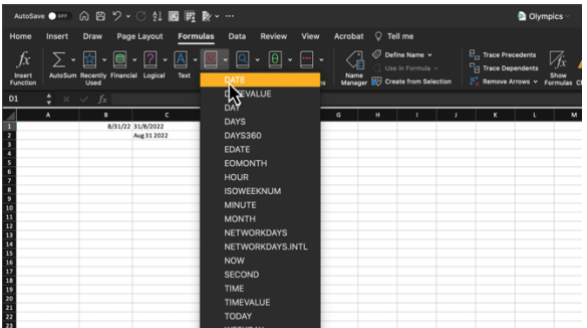
<p>0. Summary</p> 	<p>There is a lot of information in this video, and you've learned how to create basic formulas like the subtraction and addition. You've learned how to copy the formulas to adjacent cells, and you've also had a chance to use the built-in functions such as Sum and Average.</p>
<p><b>Storyboard 2.1: Formatting Date and Time</b></p>	
<p><b>Visual</b></p>	<p><b>Narration</b></p>
<p>Intro</p> 	<p>Date and time are among the very most frequent data we enter in Excel. There is a lot of computational capability in Excel when working with dates and time. On this worksheet we're going to enter and format dates and time.</p>
<p>Format data</p> 	<p>We display dates differently depending on each culture. In the U.S, months always start before dates.</p> <p>In the blank worksheet, I'm going to input the date Aug 31, 2022. In Excel, the easiest</p>



way to enter a date is to use slash. So, I'll type 8 slash 31 slash 2022. Anytime you use slash, Excel evaluates that information as if it could be a date, and if it is, it aligns the date on the right-hand side of the cell.



If I input dates in different formats with the default: 31/8/2022 or Aug 31 2022 the data in these two cells won't be aligned on the right hand side of the cell, so it is an indicator for us to recognize the format is wrong.



To examine the right date format, we can also go to the Formulas tab, and choose Date & Time in the Function Library ribbon and click on Date. Then you should insert the year (2022), month (8), and date (31), and you click OK. As a result, you will get 8/31/2022 in the default format.

Format time

When you work with time, enter them with colons. You can also choose whether a.m. or

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2												
3												
4												
5												
6												
7												
8												
9												
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11												
12												
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18												
19												
20												
21												
22												

p.m. For example, I input 10:30 pm in cell

B2.

Like dates, time will be aligned on the right-hand side of the cell.

## Storyboard 2.2: Working with Rows and Columns

### Visual

#### 1.Intro

1. Insert a column

### Narration

Oftentimes, we find we need to insert a new row or column in our worksheet.

For example, in the Olympic Athletes worksheet, I want to insert a column named Start Date in front of Closing Ceremony Date.

To do so, just choose column E, right click, and choose Insert. A new column will be inserted to the left side of the chosen column.

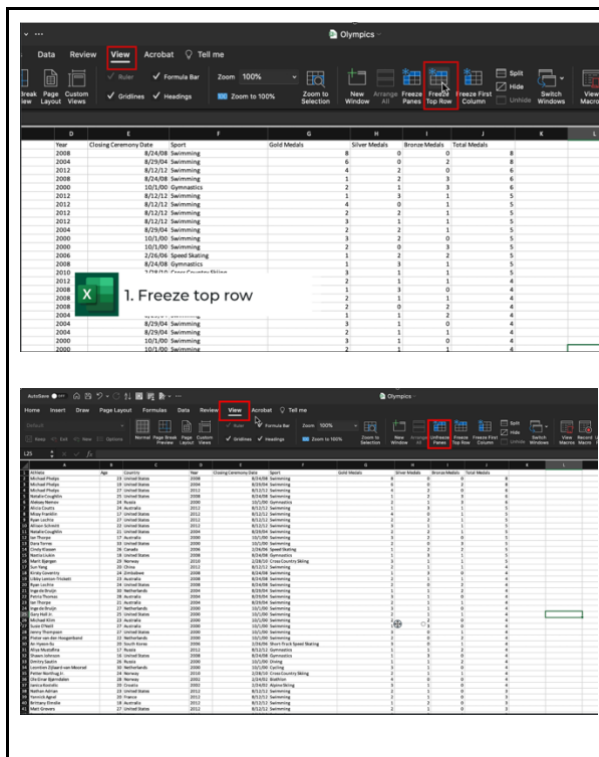
#### 2. Insert a row

2. Insert a row

Similarly, to insert a new row, just choose a row, right click, from the dropdown menu, click insert. A new row will be inserted to the top of the chosen row.







you do this, the border under row 1 is a little darker than other borders, meaning that the row above it is frozen. So, from now, when we scroll down the worksheet, we will always see the first row.

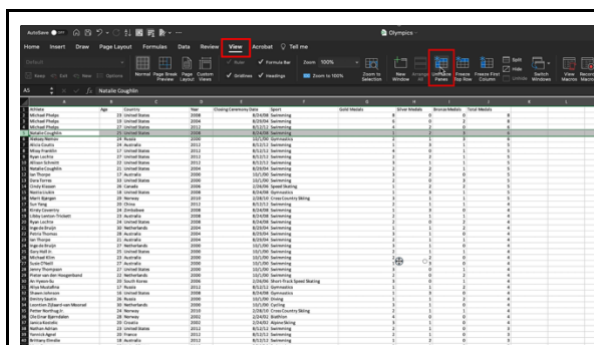
To unfreeze it, go to the view tab, click **unfreeze panes**.

## 0. Freeze multiple rows



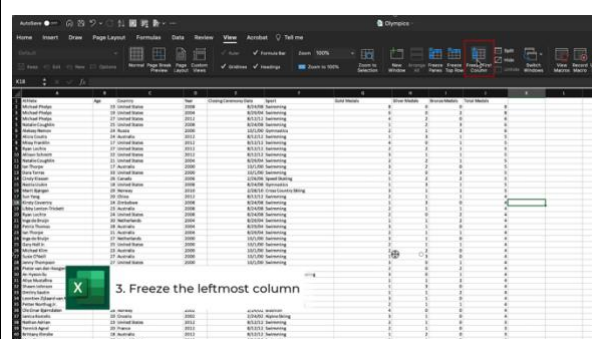
Sometimes we want to freeze multiple rows to compare the data. For example, in this file, we want to compare Michael Phelps' performance with other athletes, and thus we want to keep the first 4 rows in place. To do this, select the row below the last row you want to freeze, in our case, the 5th row, and we go to the view tab, and click Freeze Panes. So now the data related to Michael Phelps performance always stay still there when we scroll down the worksheet.



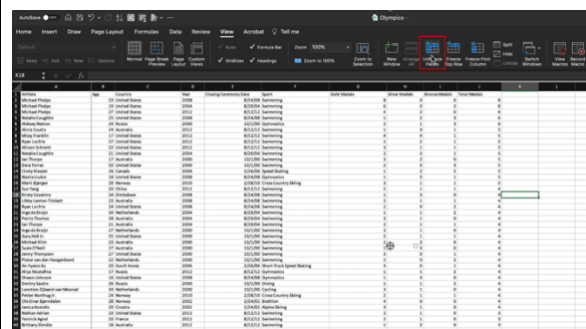


To unfreeze it, under the view tab, click Unfreeze Panes.

## 0. Freeze a column



If you'd rather freeze the leftmost column instead, on the View tab, click Freeze First Column. The line to the right of column A is a little darker than the other lines, meaning that the column to its left is frozen. Doing this, the first column stays frozen there when we scroll left or right.

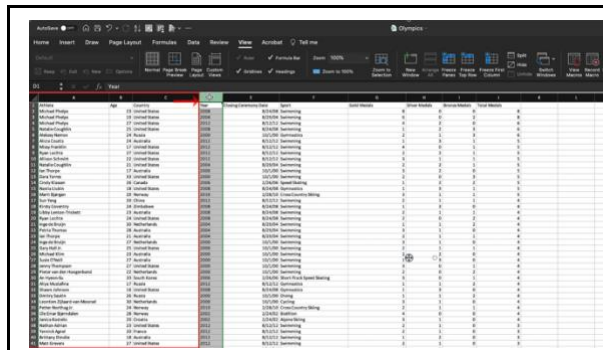


To unfreeze a column, go to the View tab, click Unfreeze Panes.

## 0. Freeze multiple columns

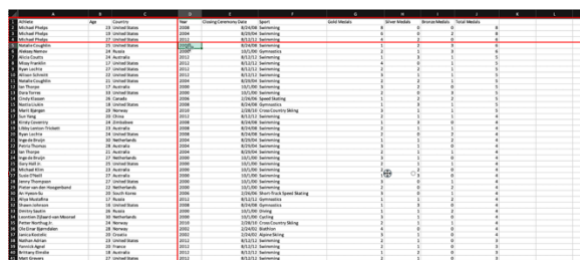
If you'd like to freeze multiple columns, select the column to the right of the last column you want to freeze. Say we want to freeze the first three columns there, we select





the column to its right, which will be column D, and then go to the view tab and click Freeze Panes.

## 0. Freeze multiple rows and columns



So now you know how to free multiple rows and multiple columns. But if I want you to freeze the first four rows and the leftmost 3 columns, what would you do? First select a cell below the last row and to the right of the last column you'd like to freeze, which is D5 in this case. Then go to the View tab and click freeze panes.

## 0. Conclusion



To sum up, you've learned how to freeze panes to keep certain data in-place. There are three key takeaways I want to highlight here. So first, to freeze multiple rows, select the row below the last row you want to freeze. Second, to freeze multiple columns, select the column to the right of the last column you want to freeze. Third, to freeze multiple



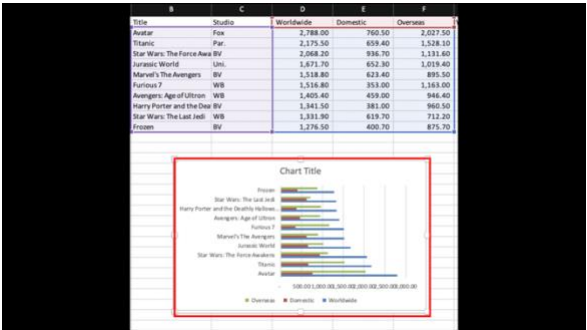
rows and columns, select a cell below the last row and to the right of the last column you'd like to freeze. After you made the selection, just go to the view tab, and click freeze panes.

## Storyboard 3.1: Creating Basic Charts

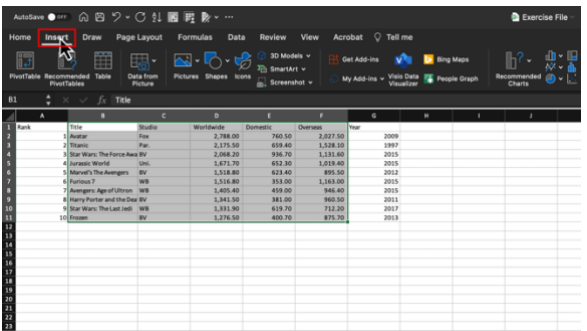
### Visual

### Narration

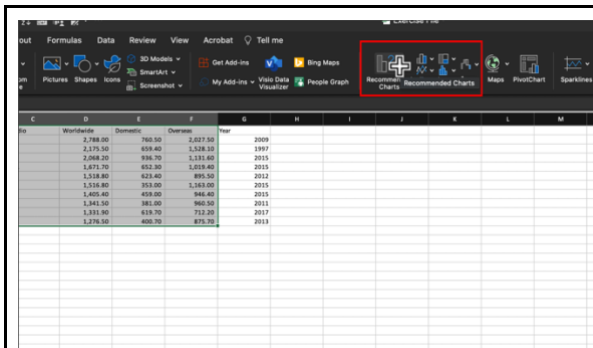
#### Intro



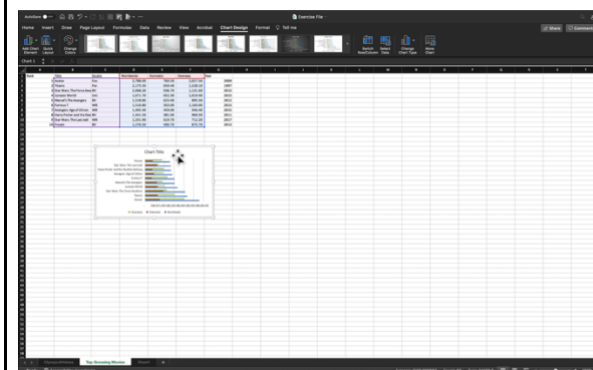
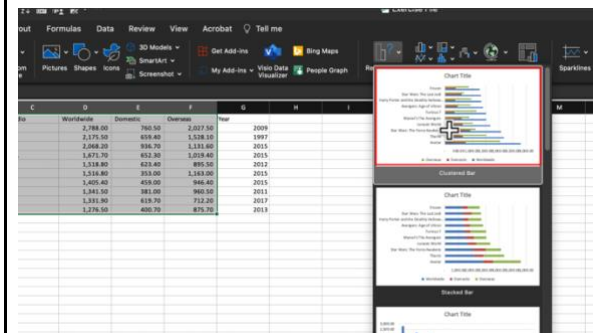
Compared with numbers in a table, charts help us to tell a better story of our data. It allows the audience to quickly process the meaning behind the numbers.



In the Top Grossing Movies worksheet, I want to quickly tell the audience the worldwide grossing, domestic grossing, and overseas grossing among several movies. So, I am going to create a chart. To do so, select the cells I want to include in the chart, including the column titles and row labels, which will be the source data for the chart. Then click **Insert** tab.



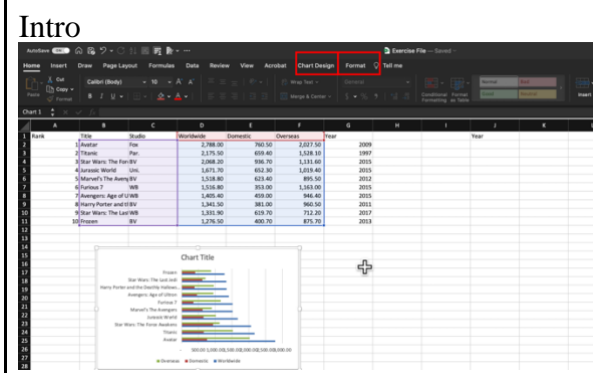
In the **Charts** group, select the chart of your preference. Here Excel will analyze your data and make its smart suggestions automatically. So, you can simply click the **recommended charts**, and scroll down the recommended options.



Once you make your selection, the chart of chosen will appear in the worksheet.

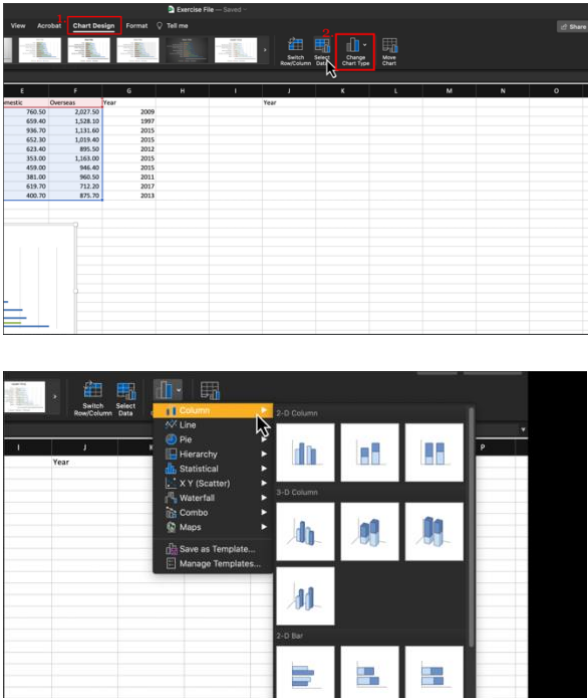
## Storyboard 3.2: Formatting Charts

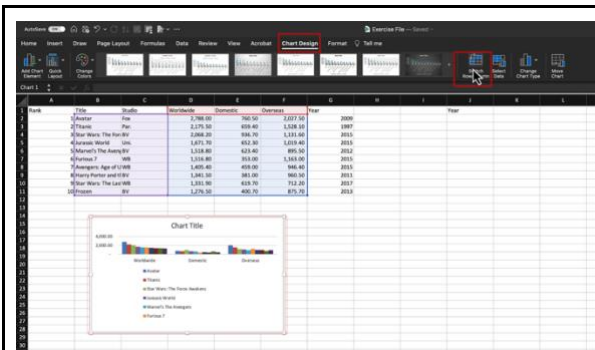
### Visual



### Narration

Once you insert a chart, a set of chart tools are arranged into two tabs (Chart Design and Format). These two tabs are only visible when the chart is selected. You can use these two tabs to modify your chart, such as

	<p>changing the chart type, switching row and column, changing the chart layout, or changing the color of a chart.</p>
<p>Change chart types</p> 	<p>If you want to change a chart type, just go to the Design tab, and click the Change Chart Type.</p> <p>A dialog box appears, and you can Select the desired chart type from it. Here instead of a bar chart, I am going to select a column chart. Then the chart of chosen will appear on the worksheet.</p>
<p>Switch row and column data</p>	<p>Sometimes when you create a chart, the data may not be grouped the way you want. In the chart below, the data are grouped by each movie with a column for the grossing. However, you can also switch the row and</p>

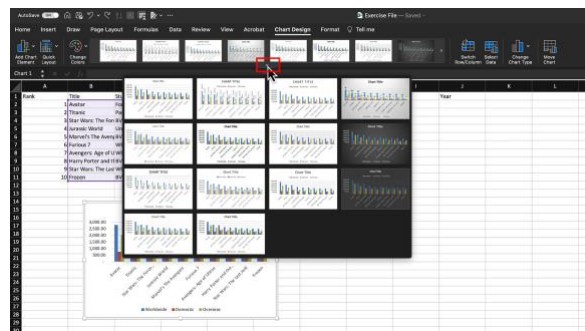


column. To do so, select the chart. From the Design tab, click the Switch Row/Column.

The chart will readjust.

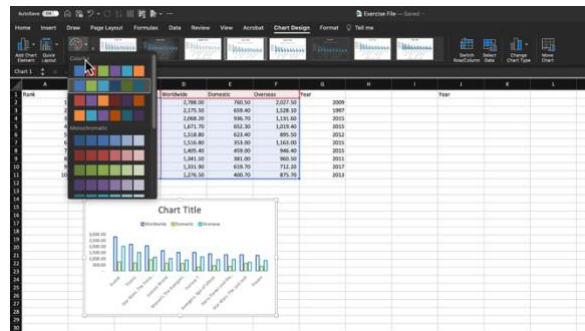
The chart still contains the same data—it's just organized differently, and thus tells the story from a different angle.

### Change chart layout



Sometimes you may want to change the layout of a chart. To do so, select the chart that you want to change, go to the Design tab. Here you can see a group of layouts that you can choose from. If you click the drop-down arrow, you will be able to see all the available layouts. Select your desired layout and the chart will update to reflect the new selection.

### Change the chart color



Another modification you can make for your chart on Excel is to change the color theme of the chart. select your chart in the worksheet, go to the chart design tab, and click change colors. You can pick the color set from the available options. The chart will

	update to reflect the new color theme of your choice.
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**APPENDIX K**  
**EXERCISE FILE**

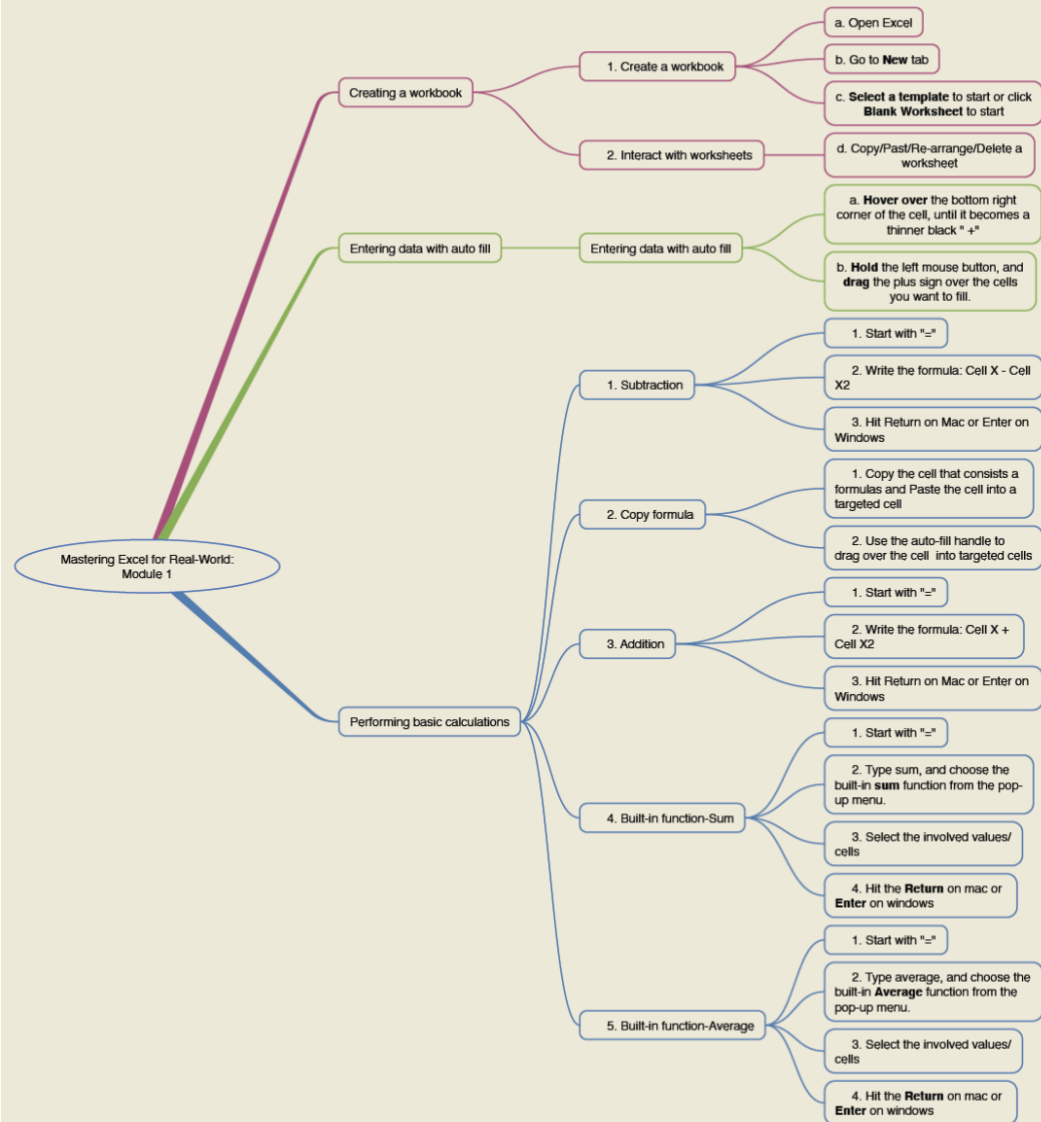
The screenshot displays a Google Sheets interface with a spreadsheet titled 'Auto Fill'. The spreadsheet has a grid with columns labeled 1 through 26 and rows labeled 1 through 26. The first row contains dates from 1/1/2018 to 1/26/2018. The second row contains the text 'Week of 1/1/2018' in column 1 and '1st Day' in column 10. A green box highlights the cell in column 10 of the third row, indicating the start of an auto-fill sequence.

[illegible][illegible][illegible]



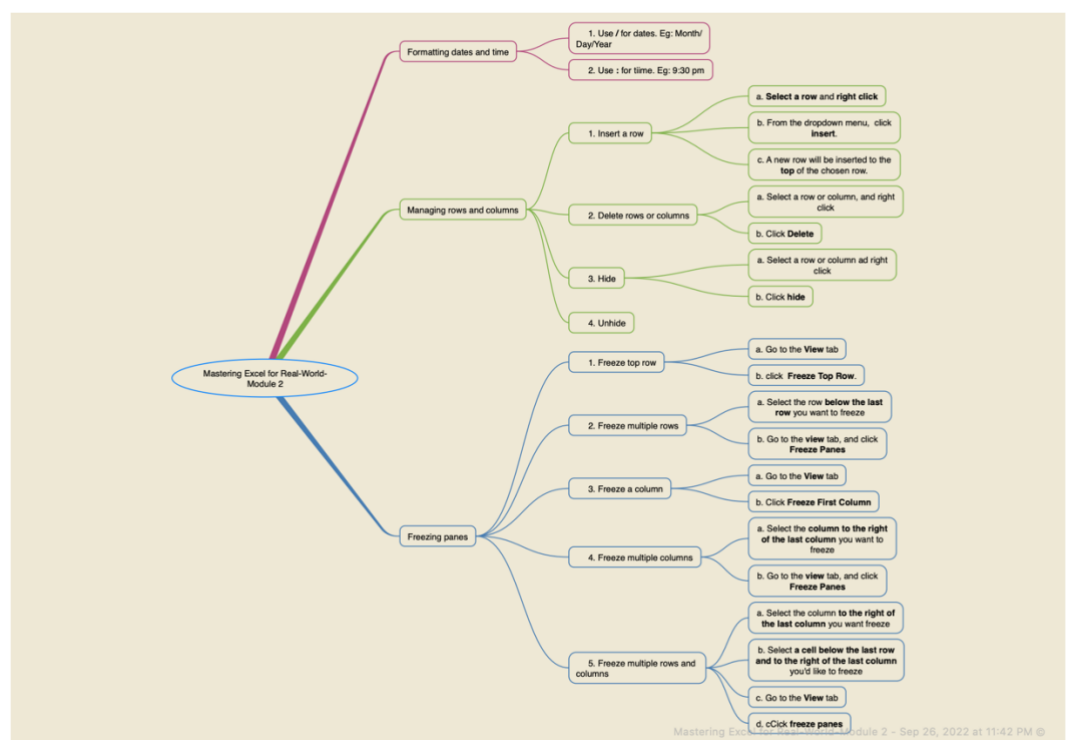
**APPENDIX L**  
**MIND MAPS**

## Module 1

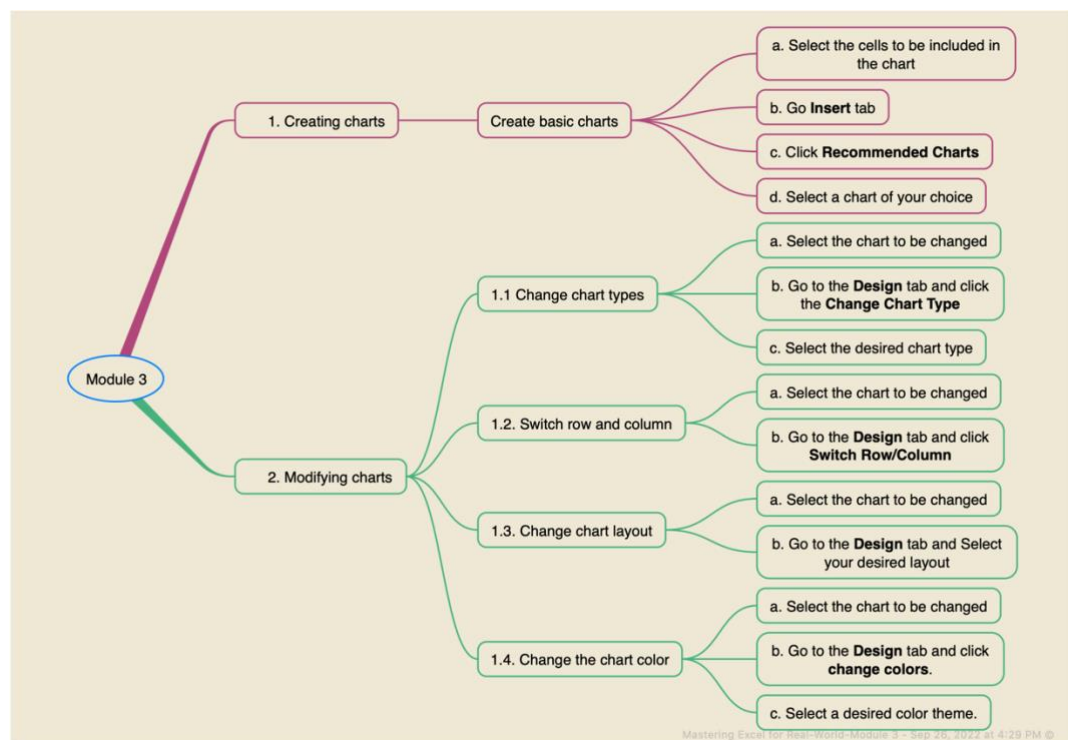


Mastering Excel for Real-world-Module 1 - Sep 26, 2022 at 4:33 PM ©

## Module 2



## Module 3



## LIST OF TABLES

**Table 1**

*Comparison of the leading provisions of pedagogy and Andragogy based on Pashko (2013) and Shostak et al. (2022).*

	Andragogy	Pedagogy
	Teaching adult	Teaching children
Independence	An adult is autonomous, an independent decision-maker	The child is addicted, directed by an adult
	Mutual exchange of training transactions	Teacher dominates – dependent learning
	Mutual assistance relationships	Mentoring relationships
Experience and communication	Ability to take/ connect with life	Limited life experience
	The multifaceted focus of communication is between everyone	One-way communication – from teacher to student
	Everyone's experience is valued as a learning resource.	Teacher experience is valued as the main course
Willingness to learn	An adult knows what he wants to learn and why.	The training course is defined in advance
	Participants are grouped into interest groups	Learners are grouped by marks and grades
Time perspective / Orientation in learning	The need to apply knowledge in life/work as soon as possible	The child learns for the future, “stores” knowledge
	Emphasis on the problem	Emphasis on the subject
	Work on today's problems today	Work on today's problems today

**Table 2***Three Types of Memory Stores based on Mayer (2020)*

Memory store	Description	Capacity	Duration	Format
Sensory memory	Briefly holds sensory copies of incoming words and pictures	Unlimited	Very brief	Iconic and auditory sensory representations
Working memory	Allows for holding and manipulating incoming sounds and images	Limited	Short	Pictorial and verbal representations
Long-term memory	Permanently stores organized knowledge	Unlimited	Permanent	Knowledge

**Table 3***Prominent Multimedia Principles with Explanation*

Multimedia principle	Explanation
Multimedia principle	“Learners learn better from words and pictures than from words alone” (Mayer, 2020, p. 34).
Modality principle	“People learn more deeply from pictures and spoken words than from pictures and printed words” (Mayer, 2020, p. 634).
Spatial contiguity principle	“People learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen.” (Mayer, 2020, p. 477).
Redundancy principle	“People do not learn better when printed text is added to graphics and narration” (Mayer, 2020, p. 433).
Coherence principle	“People learn better when extraneous material is excluded rather than included” (Mayer, 2020, p. 332)
Personalization principle	“People learn better when e-learning environments use a conversational style of writing or speaking (including using first- and second-person language), polite wording for feedback and advice, and a friendly human voice” (Clark and Mayer, 2016, p. 179).
Embodiment principle	“People learn more deeply from multimedia presentations when an onscreen instructor displays high embodiment rather than low embodiment” (Mayer, 2020, p. 772).
Segmenting principle	“People learn better when a multimedia message is presented in user-paced segments rather than as a continuous unit” (Mayer, 2020, p. 562).

Pre-training principle

“People learn more deeply from a multimedia message when they know the names and characteristics of the main concepts” (Mayer, 2020, p. 601).

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**Table 4***A comparison of face-to-face and online instruction approaches.*

	Face-to-face	Online
Visual/Oral cues	<ul style="list-style-type: none"> <li>• A rich nonverbal communication environment</li> <li>• High levels of monitoring and feedback</li> <li>• Conversation is competitive and requires confidence, especially to disagree</li> <li>• It is easier to build rapport and trust</li> </ul>	<ul style="list-style-type: none"> <li>• A more impersonal medium with reduced social cues</li> <li>• Messages are more difficult to understand</li> <li>• There is less social togetherness</li> <li>• Free to communicate for some participants</li> </ul>
Response time	<ul style="list-style-type: none"> <li>• Synchronous</li> <li>• Rapid spontaneous and free flowing dialogue</li> <li>• Fixed time and place a particular time and place</li> </ul>	<ul style="list-style-type: none"> <li>• Both synchronous and asynchronous</li> <li>• Asynchronous is more common</li> <li>• Space to reflect and think at one's own pace</li> <li>• No time and distance barriers, anytime, anywhere</li> <li>• Often takes more time</li> </ul>
Oral/text-based Communication	<ul style="list-style-type: none"> <li>• The emphasis is on listening and talking</li> <li>• Communication is quick and easy for confident speakers</li> <li>• Brief and short-lived</li> </ul>	<ul style="list-style-type: none"> <li>• The emphasis is on reading and writing, so there is a record</li> <li>• Messages/responses are often carefully thought out and written down</li> <li>• Participation takes time</li> <li>• Can increase overload</li> </ul>



**Table 5***Research steps*

Preparation	Control group	Treatment group	Post Learning
Step 1: Observed the classes, review training documentation	Step 1: Conducted pre-test	Step 1: Conducted pre-test	Step 1: Analyzed data
Step 2: Designed and developed learning material	Step 2: Delivered the online learning	Step 3: Delivered the online learning	
Step 3: Developed and validated instruments	Step 3: Conducted post-test	Step 3: Conducted post-test	
Step 4: Recruited participants	Step 4: Conducted the survey	Step 4: Conducted the survey	
	Step 5: Conducted interview	Step 5: Conducted interview	

**Table 6***Diversity of Total Student Population (Fall 2020)*

Race	Population	Percentage
White	2,739	27
Asian	2,224	22
Latino	2,114	21
International	1,325	13
Multi Race	800	8
African American	642	6
Unknown	163	2
Native Hawaiian/Pacific Islander	47	0.5
Native American	14	0.1
Total	10,068	100

**Table 7***Demographics of the Participants*

	Subgroup	Control Group	Treatment Group
Gender	Female	10	13
	Male	12	9
Ethnicity	White	5	4
	Asian	7	8
	Latino	4	3
	African American	2	3
	International	3	2
	African American	1	2
Education Level	Undergraduate	13	11
	Graduate	4	5
	Doctorate	5	6
School	School of Management	8	10
	School of Education	7	6
	School of Nursing	3	2
	School of Law	4	3
	College of Arts and Sciences	0	1

**Table 8**

*Framework of the Instructional Design*

<b>Step 1: Savvy start</b>
Step 1.1 Craft an actionable, results-oriented, and contextualized title.
Step 1.2 Describe the course clearly: Inform the learners about what they will learn.
Step 1.3 Address course goals and objectives: Explain what competency learners will obtain as a result of this learning.
Step 1.4 Inform the benefits of learning the target skills and the negative consequences of not learning them.
Step 1.5 Inform the practical relevance of the target skills to real life.
Step 1.6 Make human connections: Introduce yourself, your role at the institution and your experience in the subject matter.
<b>Step 2: Content Development</b>
Step 2.1 Segment: Organize and present information in smaller steps or chunks based on key concepts to reduce the cognitive load of working memory.
Step 2.2 Eliminate extraneous information that doesn't align with learning objectives.
Step 2.3 Introduce the names and characteristics of the main concepts before diving into the content presentation.
Step 2.4 Provided preliminary resources for the course.
Step 2.5 Present content with multimedia materials. E.g.: videos, mind maps, simulated activities, etc.
Step 2.6 Contextualize targeted skills by showing the practical use cases.
Step 2.7 Connect targeted skills with additional real-world applications/examples.
Step 2.8 Maintain conversational style rather than formal style.
Step 2.9 Record a friendly human voice with enthusiasm for narrations rather than using a machine voice.
Step 2.10 Use reflective questions to facilitate knowledge re-construction. E.g.: What is the difference between two concepts? What is your biggest takeaway from this class?
Step 2.11 Provide hands on-practice activity to facilitate knowledge retention.

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**Step 3: Content Closure**

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Step 3.1 Recap the key concepts.

---

Step 3.2 Elicit emotion and a sense of achievement.  
Highlight knowledge competency learners developed - Align with learning goals.

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Step 3.3 Provide instructional support/additional resources as needed.

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Guideline 3.4 Call to action.

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**Step 4: Learning Experience Design**

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Step 4.1 Maintain coherence: Design a coherent format throughout the learning experience, including the coherent structure of each learning module, the coherent design style of the videos, mind maps, and simulations.

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Step 4.2 Maintain spatial contiguity: Present related words and pictures spatially close to one another; Synchronize words or narration with graphics.

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Step 4.3 Maintain temporal contiguity: Present corresponding narration and images/animations simultaneously.

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Step 4.4 Add visual and audio cues that guide learners' attention to the relevant elements of the material.

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Step 4.5 De-redundancy: Remove any irrelevant information from multimedia. E.g.: animation, extra frame of a screencast video, music, etc.

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**Table 9***The summary of pre-test data for the Control and Treatment Group*

Variable	Number	Mean	SD	SE	95% Conf.	Interval
Control	22	38.11	10.81	2.3	33.32	42.90
Treatment	22	38.79	15.76	3.36	31.81	45.78
Combined	44	38.45	13.36	2.01	34.39	42.52

**Table 10**

*Independent T-test Results, and Effect Sizes for Comparing Pre-test Scores Between the Control group and the Treatment Group*

Mean Difference (Control - Treatment)	t-score df=42	p-value	Cohen's d (effect size)
0.68	0.17	0.87	0.05

**Table 11**

*The summary of post-test data for the treatment and control groups.*

Variable	Number	Mean	SD	SE	95% Conf.	Interval
Treatment	22	87.27	10.47	2.23	82.63	91.92
Control	22	79.39	9.18	1.96	75.32	83.46
Combined	44	83.33	10.51	1.59	80.14	86.53



**Table 12**

*Independent T-test Results, and Effect Sizes for Comparing Post-test Scores Between the Control and the Treatment*

Mean Difference (Control - Treatment)	t-score df=42	p-value	Cohen's d (effect size)
7.88	2.65	0.01	0.80

**Table 13***The summary of Gained Score for the Control and the Treatment group*

Gained Score	Number	Mean	SD	SE	95% Conf.	Interval
Control	22	41.28	8.43	1.80	37.55	45.02
Treatment	22	48.48	12.55	2.67	42.91	54.04
Combined	44	44.88	11.17	1.68	41.48	48.28

**Table 14**

*Independent T-test Results, and Effect Sizes for Comparing Gained Scores Between the Control and the Treatment*

Mean Difference (Control - Treatment)	t-score df=42	p-value	Cohen's d (effect size)
7.19	2.23	0.3	0.67

**Table 15**

*Descriptive Statistics, Independent T-test Results, and Effect Sizes for Comparing Prior Knowledge, Learning Results, and the Gained Score*

Variable	Control Group (N=22)		Treatment Group (n=22)		T-test (df=42)	P- value	Cohen's D
	Mean	SD	Mean	SD			
Pre-test	38.11	10.81	38.79	31.81	0.17	0.87	0.05
Post-test	79.38	9.18	87.27	10.47	2.65	0.01	0.80
Gained Score	41.28	8.43	48.48	12.55	2.23	0.3	0.67

**Table 16***The results of Shapiro-Wilk tests of Normality and Levenes's Test of Homoscedasticity*

Variable	Shapiro-Wilk		Levene's Test	
	Stat	p-value	Stat	p-value
Motivation	0.95	0.38	0.02	0.89
Autonomy	0.94	0.20	0.0	1.0
Satisfaction	0.95	0.26	0.22	0.64

**Table 17**

*Independent T-test Results and Effect Sizes for Comparing Survey Result Between the Control Group and the Treatment Group*

Variable	Control Group (n=22)		Treatment Group (n=22)		t-test		Cohen's D
	Mean	SD	Mean	SD	T-test df=42	P value	Effect size D
Motivation	38.36	3.52	41.18	3.36	2.71	0.01	0.82
Autonomy	41.00	3.48	40.82	3.58	-0.17	0.87	-0.05
Satisfaction	39.45	3.16	40.82	3.19	1.43	0.16	0.42

**Table 18***Demographic Characteristics of Individual Interviewees*

Group	Name (Pseudonym)	Gender	Ethnicity	Major	Education
Control	Lisa	Female	Asian	Education	Graduate School
	Emma	Female	Asian	Education	Graduate School
Treatment	May	Female	Asian	Education	Graduate School
	Michael	Male	White	MBA	Graduate School

**Table 19***Interview findings of the Control Group*

Interview Questions	Code	Group	Participants' Response
Q1: How was this training beneficial to you?	Learning Benefit	Control	Lisa: "Overall, I think this training is very helpful to refresh my knowledge and improve my Excel skills in a systematic way."
			Emma: "This training is very beneficial to me in terms of helping me to learn the fundamental skills and basic concepts in Excel"
		Treatment	May: "I think this training is definitely beneficial for my personal life and my work."
			Michael: "This training is very beneficial for me to learn the fundamental functions in Excel."
Q2: What captured your learning interests in the training?	Learning Engagement	Control	Lisa: "The whole training is just one hour, which makes me feel like I can just sit in front of my laptop and finish the training. And the learning objective is simple (achievable)."
			Emma: "I like the course because it is so flexible that I can complete the training anywhere. It also complements my schoolwork. I will do some research in the future, and I need to learn Excel."
		Treatment	May: "The training is short and concise. I can take it at my own convenience."
			Michael: "First, I think the course is really visually appealing. I also really like the videos. They are just two to three minutes long. Not overwhelming. You also chunked each video into a group of related concepts and added a preview of the sub-concept, which makes the content easy to digest. When demonstrating a feature, the video zoomed in, showing red rectangles, which really helped me to concentrate on the feature. And the summary at the end of each video told me what exact skill I just learned. I like the visual hints in the multiple-choice question as well. When clicking an option item, a check mark showed up, letting



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me know what I have selected.”

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Q3: What aspects of this course are helping you learn?	Learning Engagement	Control	<p>Lisa: “The course content flows smoothly and is structured very well! There were three modules, which were aligned with the learning objectives. There is no content that distracts from the learning objectives. It only covered the exact amount of knowledge. Each video in the modules is around two minutes or three minutes long.”</p> <hr/> <p>Emma: “I really liked the exercise file and the videos. The videos are very clear. I can follow the videos with the exercise file you provided. I also realized that at the end of each video, there was a summary of what I learned. There is a connection between the quiz and the content.”</p> <hr/>
		Treatment	<p>May: “I really like the guided practice (simulation), in which I can perform the exercise step-by-step. I remember one of the exercises (simulation) asked me to input the format of data exactly like I would do in Excel. And it gave me instant feedback whether I did it correctly or not. I think it’s very interesting and easy to navigate.”</p> <hr/> <p>Michael: “I think all the content is helpful, the videos and exercise files gave me a clear demo, and allowed me to follow along. The guided practice (simulation) guided me to execute a task step-by-step within the course. I think the mind map is helpful, too. If I forget something, I don’t need to take the course again, and I can just quickly scan the mind map to find the steps (procedures). There were additional learning resources provided at the end of the course. I am very interested in keep learning it.”</p> <hr/>
Q4: What do you wish to be changed in the course?	Learning Iteration	Control	<p>Lisa: “I wish the multiple-choice questions can be changed into a project-based assessment, so I can learn how to manipulate spreadsheets in real-life situations. Additionally, I think it’s hard to perform the self-practice added into each end of the video voluntarily, as I have to switch the Canvas (learning platform) into Excel.”</p> <hr/>

			<p>Emma: “Maybe add some activities, like games, drag and drop, to make it more interesting and interactive.”</p>
		Treatment	<p>May: “Maybe a real project for assessment. The multiple-choice questions are good to check my understanding, but a real project that asks me to apply what I learned in a real project will be very interesting. For example, at the end of each video, you can give a hands-on task, like give me a scenario and ask me to create a chart. That will be very interesting.”</p> <p>Michael: “It will be very helpful if you can add a brief instruction at the beginning of the guided practice. It is my first time doing this kind of activity, and I didn’t know what to do at the beginning. But I quickly figured that out.” Additionally, if you can enlarge the screens in the guided practice, like zoom-in the targeted area that would be very helpful!</p>
Q5: How might Excel training benefit you?	Learning Benefit	Control	<p>Lisa: Participant A: I think it will benefit me long-term as I will need to use it no matter what industry I will be working in.</p> <p>Emma: I might use it to run some data for my future research.</p>
		Treatment	<p>May: “I think next time when I place an order with my friends, I will be able to use Excel to calculate who spent how much money. Also, I will be able to use Excel to calculate my students’ grades!”</p> <p>Michael: “I am doing a project for the International Marketing course. Excel helps me organize my data for further analysis”</p>
Q6: What difficulties and barriers have you encountered during this training?	Learning iteration	Control	<p>Lisa: “This training is very easy to follow, and I didn’t encounter any difficulties or barriers in this training.”</p> <p>Emma: “I have encountered several technical difficulties, like playing a video in the course. If there is a chatting box that can allow me to report the errors or interact with the instructor for technical assistance, that will be very</p>

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helpful.”

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Treatment

May: “Overall, it’s very easy to follow! But in the guided practice, I probably did not follow the instruction and clicked somewhere else. It gave me an error message that I did it wrong, but I didn’t know how I did it wrong.”

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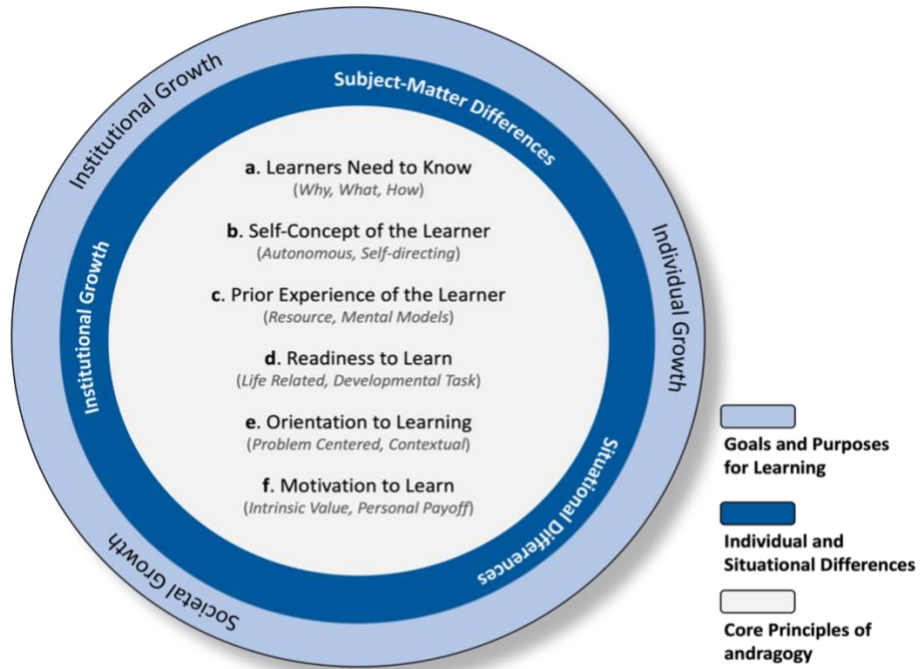
Michael: “I didn’t encounter any major difficulty in the course. But I think a brief instruction about how to navigate the course and the guided practice will be very helpful. It’s my first time learning this interface (storyline). Even though I can intuitively figure out how to navigate, a quick walk-through will still be helpful.”

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## LIST OF FIGURES

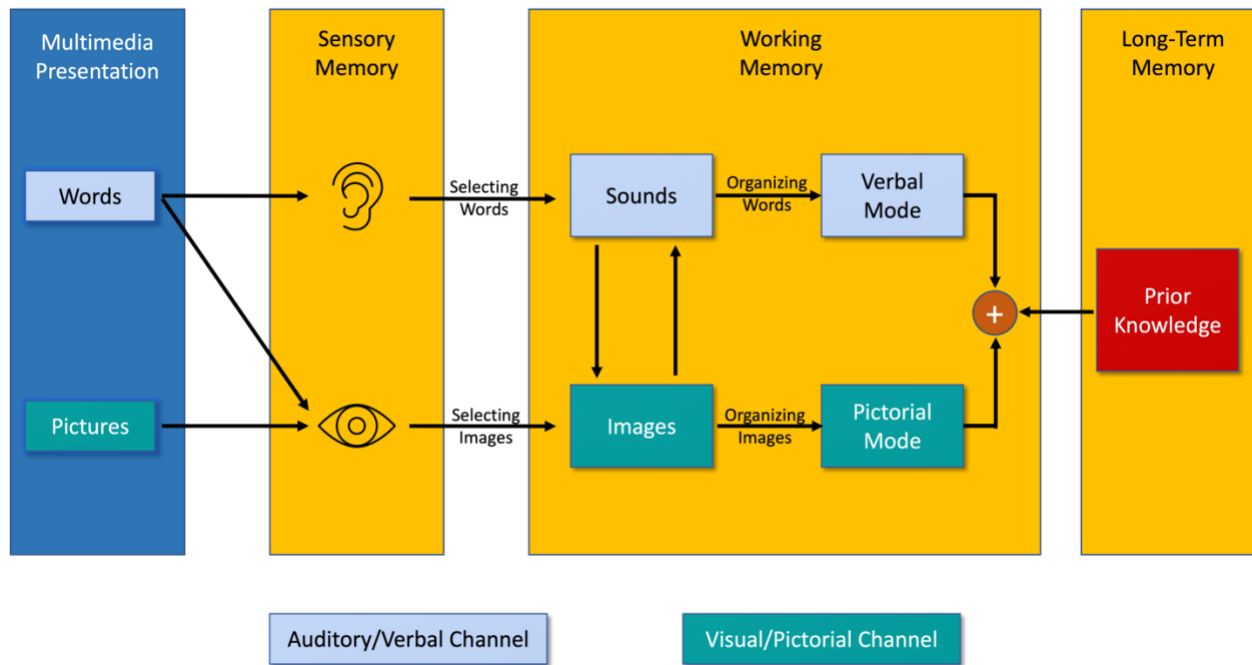
**Figure 1**

*Andragogy in Practice Model (APM) after Knowles et al. (1998)*



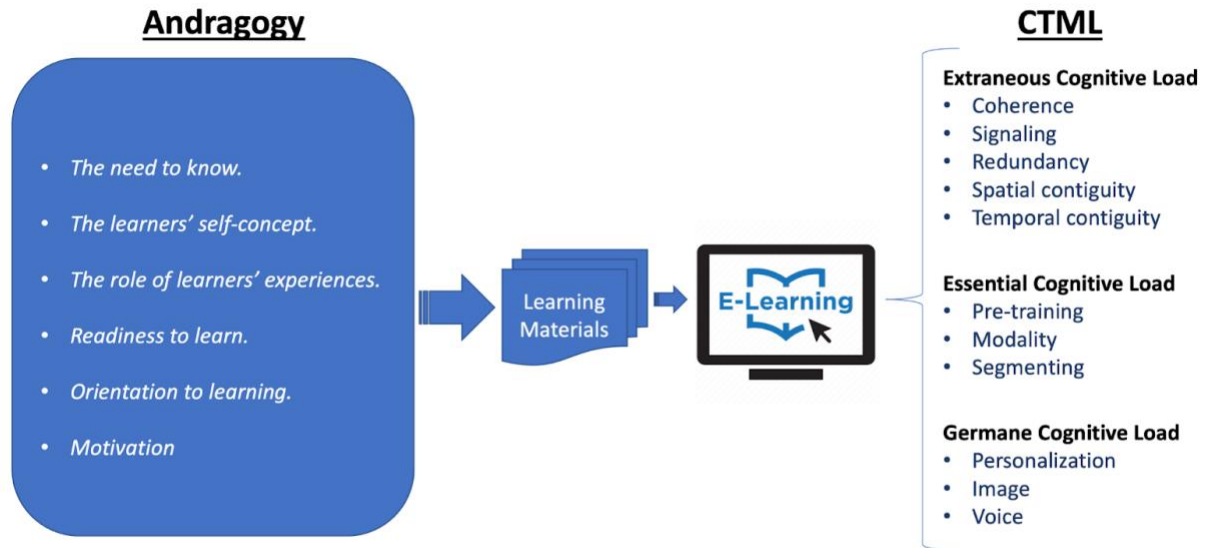
**Figure 2**

*Mayer's Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2020)*



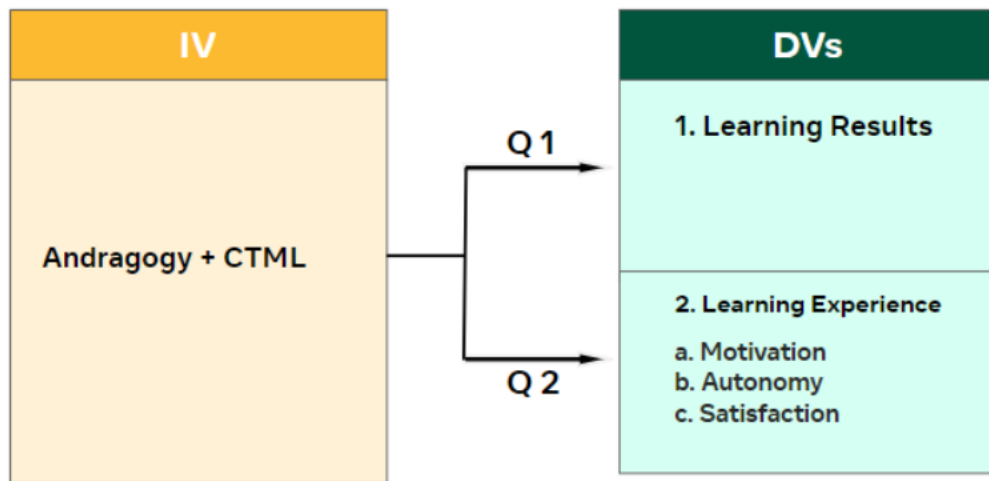
**Figure 3**

*Integrating theoretical frameworks into e-learning design*



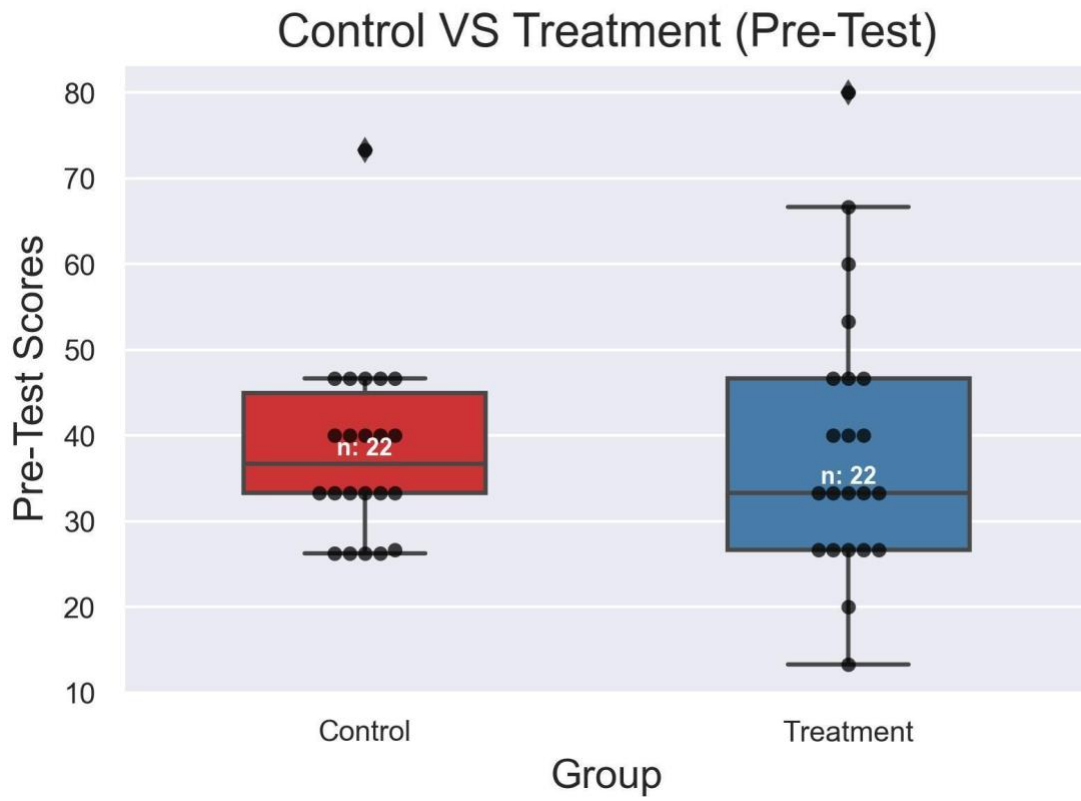
**Figure 4**

*Research Design*



**Figure 5**

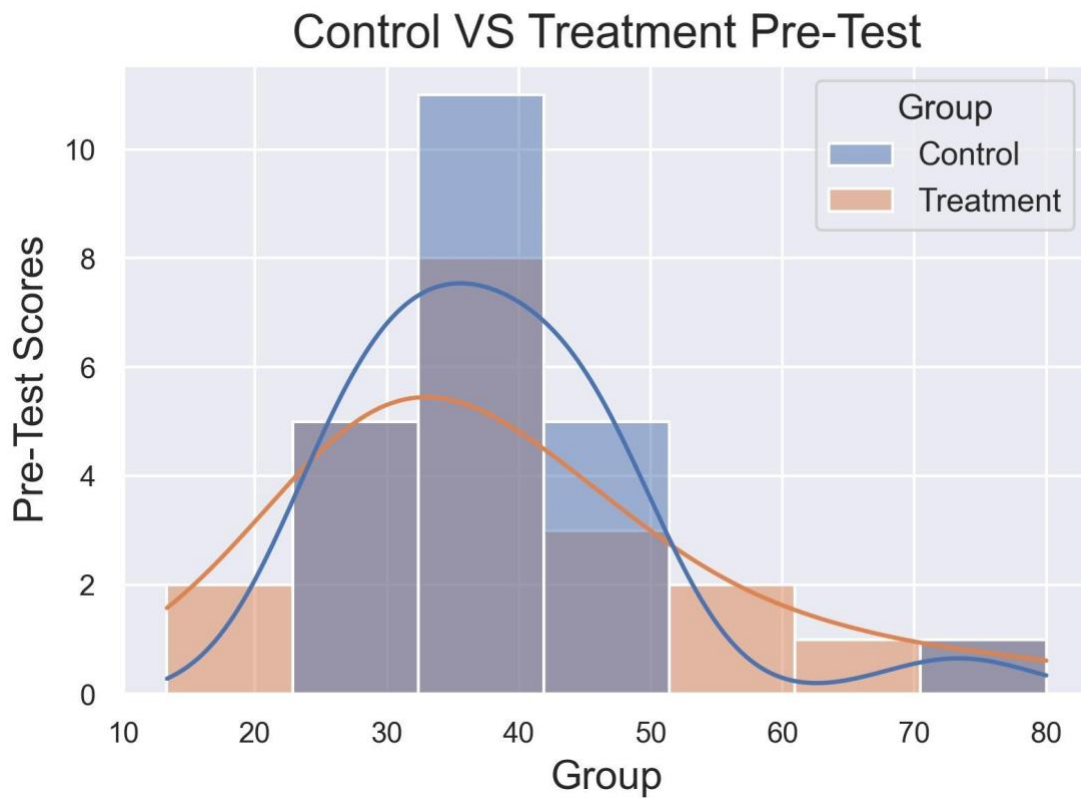
*Boxplots of Pre-test Results for Students in the Control Group and the Treatment Group*





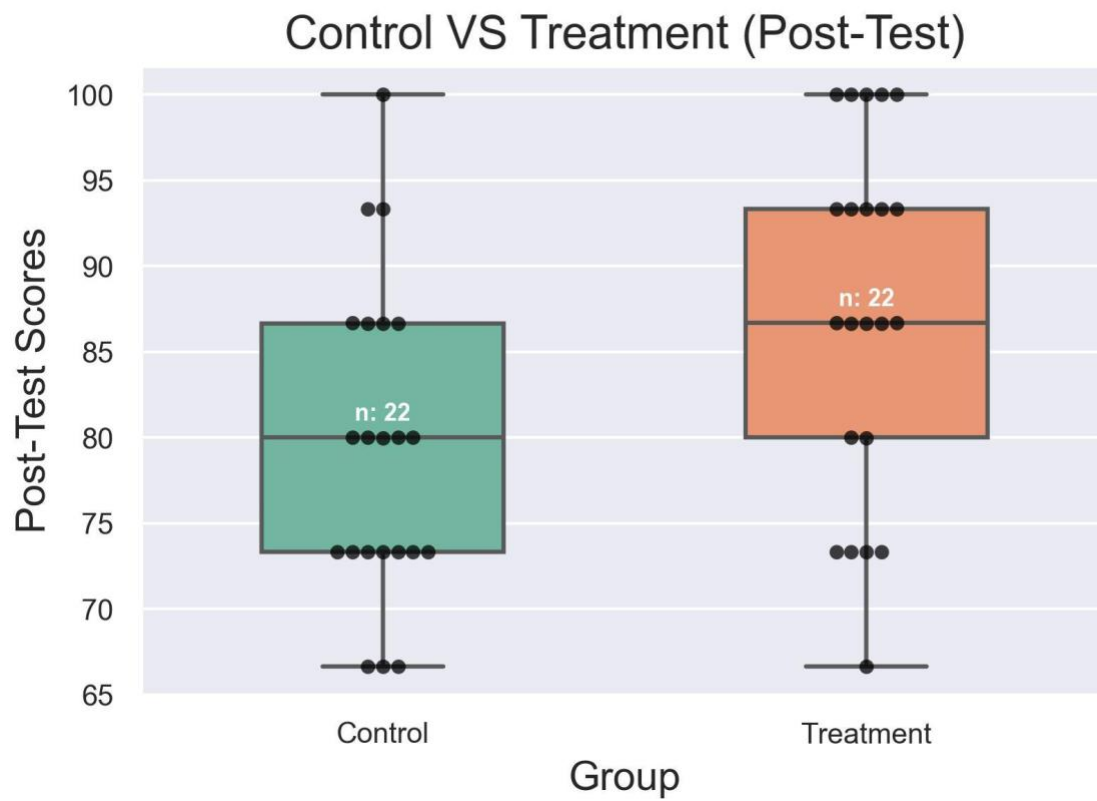
**Figure 6**

*Histogram Plots Overlaid by Smoothed Curves Demonstrating the Distribution of Pre-test Results for Students in the Control Group and Treatment Group*



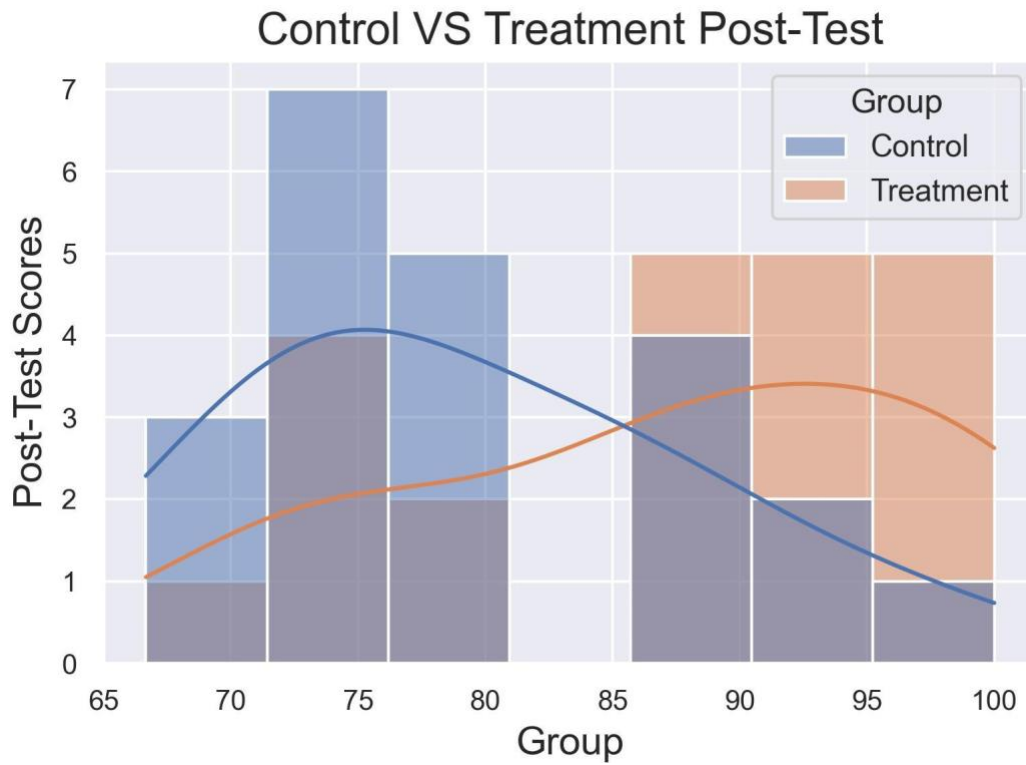
**Figure 7**

*Boxplots of Post-test Results for Students in the Control and Treatment Group*



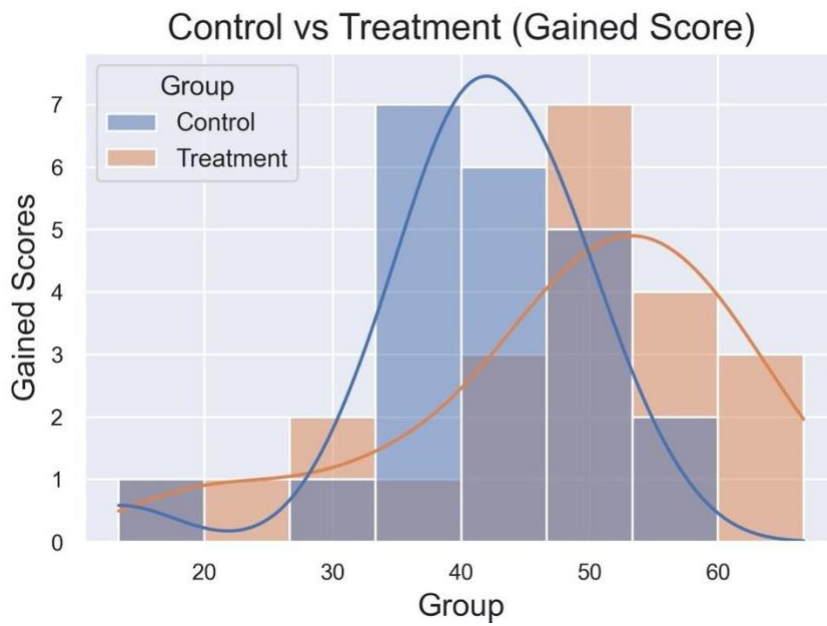
**Figure 8**

*Histogram Plots Overlaid by Smoothed Curves Demonstrating the Distribution of Post-test Results for Students in the Control and Treatment Group*



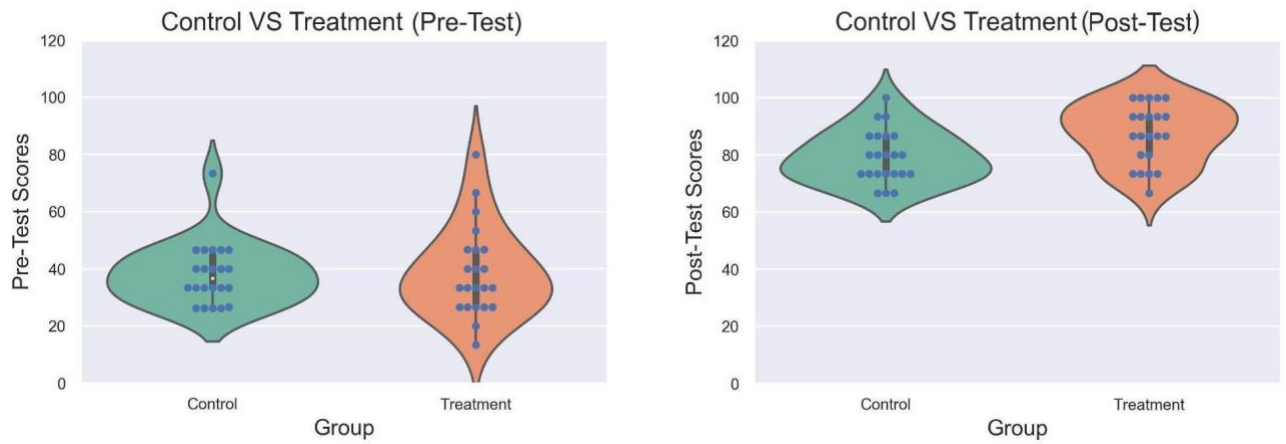
**Figure 9**

*Histogram Plots Overlaid by Smoothed Curves Demonstrating the Distribution of Gained Scores for Students in the Control Group and Treatment Group*



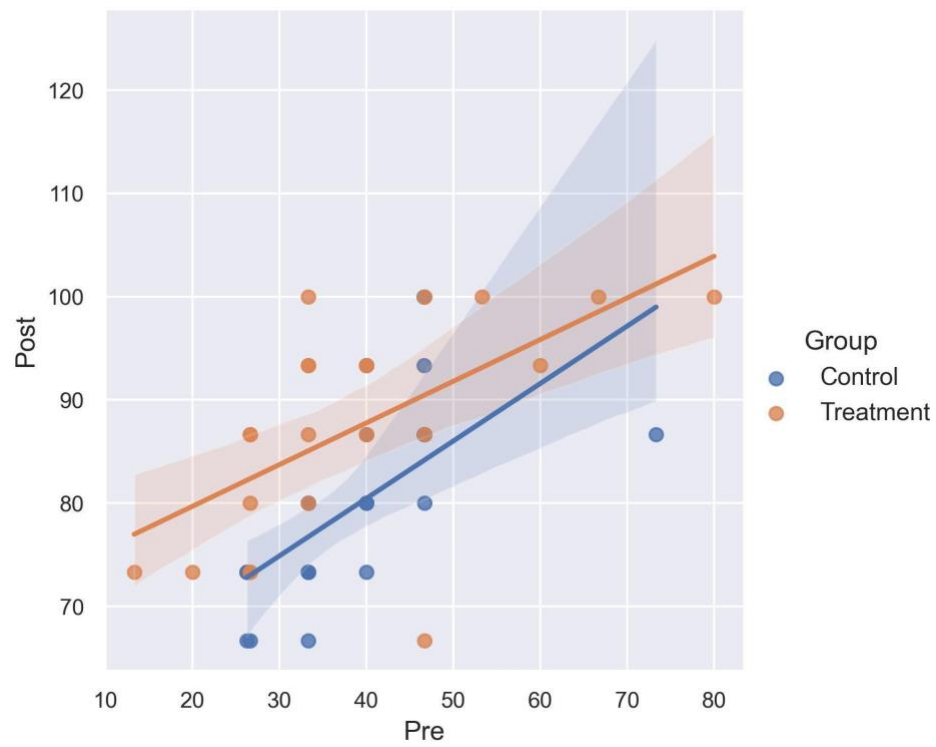
**Figure 10**

*Violin Plots of the Pre-test (left) and Post-test (right) for Students in the Control and the Treatment Group*



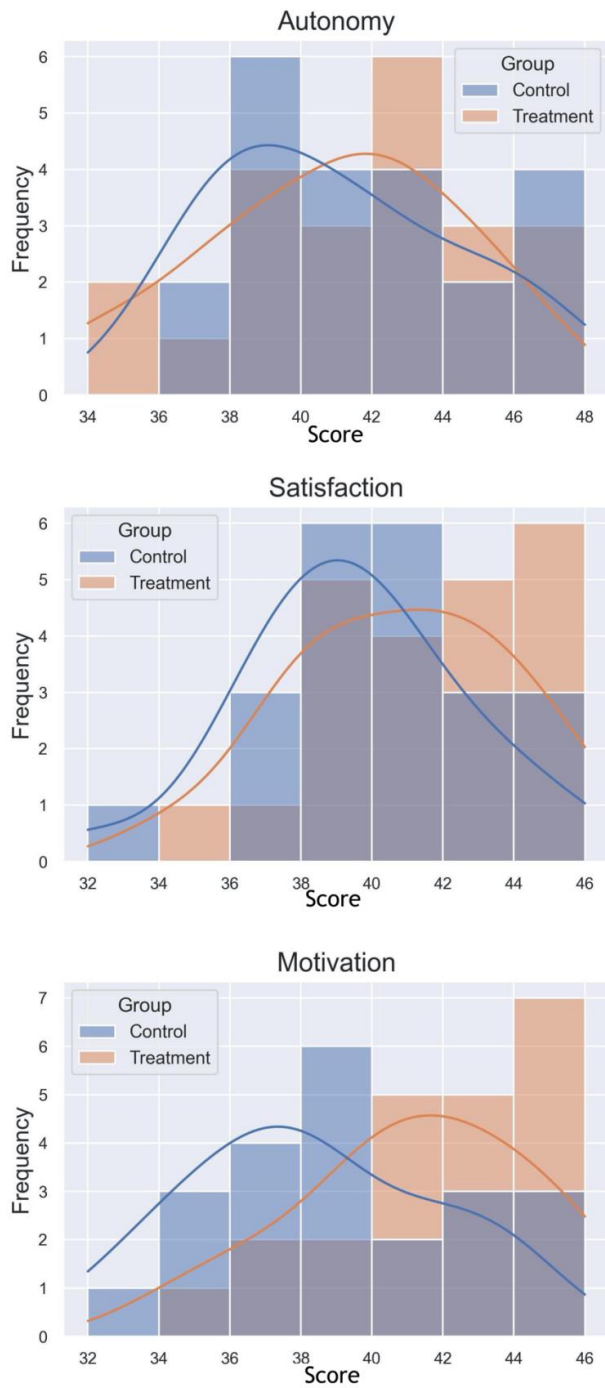
**Figure 11**

*Regression plot of the Pre-test (horizontal axis) and Post-test (vertical axis) for Students in the Control and the Treatment Group*



**Figure 12**

*Histograms of Survey Results for Students' Learning Experiences Regarding Learning Motivation, Autonomy, and Satisfaction*



**Figure 13**

*Boxplots of Survey Results for Students' Learning Experiences Regarding Learning Motivation, Autonomy, and Satisfaction*

