

## Curriculum Vitae

Mary Lynn McPherson, PharmD, MA, MDE, BCPS  
Professor and Executive Director, Advanced Post-Graduate Education in Palliative Care  
Executive Program Director, Online Doctor of Philosophy, Master of Science and  
Graduate Certificates in Palliative Care  
Department of Practice, Sciences, and Health Outcomes Research  
School of Pharmacy, University of Maryland, Pharmacy Hall, 20 N. Pine Street  
Baltimore, Maryland 21201 [mmcphers@rx.umaryland.edu](mailto:mmcphers@rx.umaryland.edu) | [mlm@pharmsmart.org](mailto:mlm@pharmsmart.org)  
[graduate.umaryland.edu/palliative](http://graduate.umaryland.edu/palliative)

PhD, Health Professions Education, 2023

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## Academic Appointments / Teaching

2016 – present	Professor and Executive Director, Advanced Post-Graduate Education in Palliative Care School of Pharmacy, University of Maryland
2016 – present	Executive Program Director, Online Doctor of Philosophy, Master of Science, and Graduate Certificate Program in Palliative Care, University of Maryland, Baltimore
2020 – present	Adjunct Professor University of Maryland School of Medicine
2016 – present	Member, Graduate Faculty University of Maryland, Baltimore Graduate School
2016 – present	Palliative Care Fellowship Director University of Maryland School of Pharmacy
2014 – present	Instructional Systems Development Fellowship Director University of Maryland School of Pharmacy
2006 – 2015	Adjunct Professor School of Nursing, University of Maryland at Baltimore
1996 – present	Residency Program Director PGY2 Pharmacy Practice Residency in Pain and Palliative Care

2004 – present      Clinical Pharmacy Consultant – AccentCare (formerly Seasons Hospice and Palliative Care), national

### **Teaching Experience**

#### **Online Graduate Studies in Palliative Care (Graduate Certificates, Master of Science, Doctor of Philosophy)**

##### **Coursemanager:**

- Principles and Practice of Hospice and Palliative Care (PALC 601), 2016 – present
- Principles and Practice of Palliative Care Education (PALC 602), 2016 – present
- Symptom Management in Advanced Illness (PALC 605), 2016 – present
- Advanced Pain Management and Opioid Dosing (PALC 615), 2016 – present
- Advanced Disease State Management (PALC 612), 2016 – present
- Clinical Management of Special Patient Populations (PALC 607), 2016 – present
- Advanced Team-Based Palliative Care (PALC 617), 2016 – present
- Study Design and Critical Appraisal of Evidence (PALC 660) 2023 - present

##### **Doctor of Pharmacy - Didactic Courses**

- Palliative Care Imperative (PHMY 5010), 2018 – present (Coursemanager)

##### **Lecturer / Instructor:**

- Applied Science and Therapeutics, 2015 – present
- General Patient Management, 2014 – present
- Pharmacotherapy I (PHAR 569), 2111 – present
- Pharmacotherapy II (PHAR 570), 2012 – present
- Health Policy Systems (PHAR 5010), 1999 – present

## **Doctor of Pharmacy - Experiential Courses**

- Patient Care Elective – Palliative Care (APPC 480), 1990 – present

## **Fellows and Residents Precepted**

Palliative Care Fellowship - 12 fellows trained, from 2018 - present

Instructional Design Fellow/Palliative Care Residency – 1 fellow trained, 2014-2016

Palliative Care Residency – 38 residents trained, 1996 - present

## **Education**

- |             |   |
|-------------|---|
| 2023        | PhD, Health Professions Education, July 2023<br>University of Maryland, Baltimore   |
| 2016        | Master of Distance Education and eLearning: Teaching and Training (MDE), University of Maryland University College (UMUC)     |
| 2014        | Master of Arts, Instructional Systems Development (MA)<br>University of Maryland Baltimore County (UMBC)                      |
| 2012        | Selected for Dr. J. Marvin Cook Outstanding Student Award   |
| 2012        | Graduate Certificate – Instructional Systems Design, August 2013<br>Graduate Certificate – Instructional Technology, Aug 2013 |
| 1986        | Doctor of Pharmacy Degree<br>Minor in Pharmacokinetics<br>School of Pharmacy, University of Maryland at Baltimore             |
| 1982 – 1984 | Bachelor of Science Pharmacy Program<br>School of Pharmacy, University of Maryland at Baltimore                               |
| 1976        | Associate of Arts Degree, Business and Public Administration<br>Anne Arundel Community College, Arnold, Maryland              |

**Additional Training – available upon request**

### **Honors and Certifications (1983 – 2017 available upon request)**

- 2023 Inaugural Distinguished Educator for Outstanding Mentor, University of Maryland, Baltimore Leaders in Education: Academy of Presidential Scholars, April 2023.
- 2023 Most Likely to Teach Life Lessons  
Graduating Doctor of Pharmacy Class 2023
- 2022 AAHPM Distinguished Hospice Interdisciplinary Team Member Award
- 2022 Fellow, American Academy of Hospice and Palliative Medicine
- 2020 Selected for Phi Kappa Phi Honor Society, March 2020
- 2019 University System of Maryland Board of Regents Faculty Award, Award for Teaching Excellence (Teacher of the Year), 2019.
- 2018 Debra Sivesind Career Award for Outstanding Contributions to Palliative Care, MD Anderson Cancer Center
- 2018 Cardinal Health Generation Rx Champions Award (for a pharmacist who has demonstrated outstanding commitment to raising awareness of the dangers of prescription drug abuse). Maryland Pharmacists Association.
- 2018 Named as a “Visionary in Hospice and Palliative Medicine”  
American Academy of Hospice and Palliative Medicine

### **Licensure**

Maryland, 1986, by examination

## **Publications**

### **Books:**

McPherson ML, Gillespie D. *Food/Drug Counseling Guidelines for Home Care Nurses*. Union Memorial Hospital, 1988.

Ferris F, McPherson ML. *Pharmacy Policies and Procedures Manual for Home Infusion*. Med-Pass, 1992. Updated 1993, 1994, 1995, 1996, 1997, 1998.

McPherson ML. *Ambulatory Care Clinical Skills Program: Type 2 Diabetes Mellitus*. American Society of Health Systems Pharmacists, 2000.

McPherson ML. *Demystifying Opioid Conversion Calculations: A Guide for Effective Dosing*. American Society of Health Systems Pharmacists, 2010.

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McPherson ML, Costantino RC, McPherson AL, Bruera E, Davis M. *50 Pharmacotherapy Studies every Pharmacotherapy Provider Should Know*. Oxford University Press, in-press (2023).

Costantino RC, McPherson ML, McPherson AL, Costantino J. *Goal Concordant Prescribing: Deprescribing in Serious Illness*. Oxford University Press, in-press (2023).

### **Chapters/Monographs (21 additional chapters available upon request):**

Mendoza K, Geiger-Hayes J, McPherson ML. Drug Interactions. In: Yennurajalingam, S, Bruera E, ed. *Hospice and Palliative Medicine and Supportive Care: Flashcards and Handbook*, Oxford University Press, 2018.

Bemben N, McPherson ML. Palliative Care. In: DiPiro JT, Yee GC, Haines ST, Nolin TD, Ellington VL, Posey LM. *Pharmacotherapy: A Pathophysiologic Approach*. McGraw-Hill Medical 2019.

McPherson AL, McPherson ML, Paice J. Opioid Pharmacotherapy. In: Berger A, O'Neill JF. *Pediatric and Adult Palliative Care and Supportive Oncology*, 5<sup>th</sup> ed. Wolters Kluwer Health, Inc., 2021.

Uritsky TJ, Mendoza K, McPherson ML. Frequent Pharmacologic Interactions in Palliative Care. In: Yennurajalingam S, Bruera E. *Oxford American Handbook of Hospice and Palliative Medicine*. Oxford University Press, New York, 2022.

McPherson ML. Opioid Conversion Calculations. In: Herndon C. *What Do I Do Now? Palliative Care Series*. Oxford University Press, 2022.

McPherson ML, Geiger J. Palliative Care. In: DiPiro JT, Yee GC, Haines ST, Nolin TD, Ellington VL, Posey LM. *Pharmacotherapy: A pathophysiologic approach*. McGraw-Hill Medical, 2022.

Davis MP, McPherson ML. Which opioids are safest and most effective in patients with renal or hepatic failure? In: Goldstein NE, Morrison RS, Woodrell C. *Evidence-Based Practice of Palliative Medicine*, 2<sup>nd</sup> ed. Elsevier, New York, 2023. In press.

McPherson ML, Kitko L. Interprofessional Palliative Care Education in Academic Settings. In: Head B, Donesky D, Wallace C, Saks N, Milic M. *Textbook on Interprofessional Palliative Care*. Oxford University Press, New York, 2023. In press.

### **Journal Articles (130 additional articles published, available upon request)**

McPherson ML, Walker KA. How to include a pharmacist in the palliative care mix [Internet]. *Center to Advance Palliative Care Palliative in Practice Blog* (Leadership Section). October 2019. Available from: <https://www.capc.org/blog/how-include-pharmacist-palliative-care-mix/>

McPherson ML. Reviewer Report, on Kremer HJ. Time to initiate randomized controlled clinical trials with methadone in cancer patients [version 1; peer review: 1 approved]. *F1000Research* 2019;8:1835. <https://f1000research.com/articles/8-1835/v2>

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Lantz TL, Noble BN, McPherson ML, Tjia J, Colangeli HN, Ferris RE, Bearden DT, Furuno JP. Frequency and characteristics of patients prescribed antibiotics on admission to hospice care. *Journal of Palliative Medicine*. 2022;25(4):584-590. <https://doi.org/10.1089/jpm.2021.0062>

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Sullivan DR, Iyer AS, Enguidanos S, Cox, CE, Farquhar M, Janssen DJA, Lindell KO, Mularski RA, Smallwood N, Turnbull AE, Wilkinson AM, Courtright KR, Maddocks M, McPherson ML, Thornton JD, Campbell ML, Fasolino TK, Fogelman PM, Gershon L, Gerson T, Hartog C, Luther J, Meier DE, Nelson JE, Rabinowitz E, Rushton CH, Sloan DH, Kross EK, Reinke LF, on behalf of the American Thoracic Society, American Academy of Hospice and Palliative Medicine, Hospice and Palliative Nurses Association, and Social Work Hospice and Palliative Care Network. Palliative care early in the care continuum among patients with serious respiratory illness. *American Journal of Respiratory and Critical Care Medicine*. 2022; 206(6): e44–e69. <https://doi.org/10.1164/rccm.202207-1262ST>

Wu DS, Mehta AK, Brewer CB, et al. Defining Clinical Excellence for Palliative Care Specialists: A Concept Whose Time Has Come. *American Journal of Hospice and Palliative Medicine*. 2022;39(12):1377-1382.  
<https://doi.org/10.1177/10499091211073968>

VandeKieft G, McPherson ML. Pharmacists participating in advanced pain management modalities for refractory pain. *Pharmacy Times*. 2022. Available at:  
<https://www.pharmacytimes.com/view/pharmacists-participating-in-advanced-pain-management-modalities-for-refractory-pain>

### **Miscellaneous Publications (available upon request)**

### **Grants and Contracts (full grant history available upon request)**

- 2013 Department of Health and Mental Hygiene, State of Maryland  
“Controlled Dangerous Substance Emergency Preparedness Plan”  
\$600,970; Co-Principal Investigator
- 2014 Office of Health Care Quality Grant Application, State of Maryland  
“Improvements in Knowledge, Skills and Attitudes Regarding Medication Management in Patients with Advanced Illnesses: An Educational Intervention for Surveyors in the State of Maryland.”  
\$101,728.58, Principal Investigator
- 2016 The Center for Interprofessional Education at the University of Maryland, Baltimore, \$10,000, Principal Investigator

### **Presentations**

### **Posters and Papers Read at Scientific or Professional Meetings (228 additional references available upon request)**

Stevens A, Watson K, Walker K, McPherson ML. Retrospective analysis of CHA2DS2-VASc and HAS-BLED scores for hospitalized palliative care patients with atrial fibrillation. 2022 Annual Assembly (AAHPM/HPNA), February 2022, Poster presentation, Virtual.

Borris J, Walker K, McPherson ML. Delphi consensus to identify medication realignment when transitioning from palliative care to hospice. 2022 Annual Assembly (AAHPM/HPNA), February 2022, Poster presentation, Virtual.

Stevens A, Walker K, Costantino R, McPherson ML. Evaluation of strategies to enhance hospice patient and family's knowledge and confidence of commonly used medications. 2022 Annual Assembly (AAHPM/HPNA), February 2022, Poster presentation, Virtual.

Calabrese M, Shaya F, Palumbo F, McPherson ML, Villalonga-Olives E, Zafari Z, Mutter R. Short-term healthcare resource utilization associated with CDC-informed opioid thresholds among commercially insured new chronic opioid users. AcademyHealth Annual Research Meeting, June 2022.

McPherson ML. Calculating conversions in opioid conversions. Food and Drug Administration (FDA) Center for Drug Evaluation and Research (CDER) Public Virtual Scientific Workshop Morphine Milligram Equivalents: Current Applications and Knowledge Gaps, Research Opportunities, and Future Directions. Virtual. June 2021.

Furuno JP, Noble BN, Fromme EK, Hartung DM, Tjia J, McPherson ML, Teno JM. Decreasing frequency of opioid prescribing on discharge to hospice care. American Academy of Hospice and Palliative Medicine/Hospice and Palliative Nurses Association Annual Assembly. San Diego, CA. March 2020 (oral presentation).

Noh YuJin, McPherson ML. Motivating factors for participating in the Master of Science in palliative care. Society of Pain and Palliative Care Pharmacists Annual Meeting. May 2020, Virtual Poster Session.

Chae SG, Walker K, McPherson ML. Delphi study of opioid stewardship programs in hospice setting. Society of Pain and Palliative Care Pharmacists Annual Meeting. May 2020, Virtual Poster Session.

Chae SG, Walker K, McPherson ML. Assessing conversion to transdermal fentanyl or methadone during transition on hospice admission. Society of Pain and Palliative Care Pharmacists Annual Meeting. May 2020, Virtual Poster Session.

Cook H, Chae SG, Walker K, Borris J, McPherson ML. Evaluation of peak inspiratory flow rate in palliative care patients: A pilot program. Society of Pain and Palliative Care Pharmacists Annual Meeting. May 2020, Virtual Poster Session.

Cook H, Kaiser K, Walker K, McPherson ML. Assessment of students' knowledge, skills and attitudes after comprehensive pain assessment training. Society of Pain and Palliative Care Pharmacists Annual Meeting. May 2020, Virtual Poster Session.

Chae S, Walker K, McPherson ML. Assessing conversion to transdermal fentanyl (TDF) or methadone during transition on hospice admission. Poster presentation at PainWeek 2020. September 2020, Virtual Conference.

Cook H, Kaiser K, Walker K, McPherson ML. Assessment of students' knowledge, skills and attitudes after comprehensive pain assessment training. Poster presentation at PainWeek 2020. September 2020, Virtual Conference.

Colangeli HN, Noble BN, McPherson ML, Tija J, Lantz TL, Ferris RE, Bearden DT, Furuno JP. Antibiotic use among hospice patients in the final week of life. American College of Clinical Pharmacy Annual Meeting. October 2020, Virtual.

## **Abstract**

Title: The Effect of Medication Information Delivery Format on Cognitive Load and Knowledge Retention of Informal Caregivers

Mary Lynn McPherson, Doctor of Philosophy, 2023

Dissertation Co-Directed by:

Christina Cestone, PhD; Assistant Vice Provost of Faculty Affairs; Executive Director, Faculty Center for Teaching and Learning; Program Director and Associate Professor, Health Professions Education (HPE), Graduate School, University of Maryland, Baltimore

Violet Kulo, EdD, MS, MA; Associate Professor and Program Director for the MS in Health Professions Education (HPE), Graduate School, University of Maryland, Baltimore.

Informal caregivers (IFCs) are tasked with many responsibilities in patient care, including medication management. Many IFCs feel ill-prepared for this responsibility, and it is incumbent on health care professionals to provide education and ensure IFCs competence in medication management. One common strategy is to provide a medication information leaflet to the IFC to prepare them for this role. Designing medication information leaflets using sound educational principles, such as an infographic designed according to the cognitive theory of multimedia learning (CTML), may optimize knowledge retention and decrease cognitive load for IFCs. The purpose of this randomized, experimental study was to investigate the impact of medication information delivery format on immediate retention of medication information and cognitive load of IFCs of patients with a serious illness. Using purposive sampling, 120 IFCs who have provided some element of

medication management for patients diagnosed with a serious illness, including patients who may have been receiving hospice or palliative care services were recruited. Study participants were randomly assigned in either the experimental group or the control group. The experimental group viewed an infographic on the medication hydromorphone, followed by a knowledge quiz, and a self-assessment of cognitive load. This was followed by a second infographic on hydroxyzine, the quiz, and cognitive load assessment. The control group went through the same steps but viewed a text-only medication leaflet. Statistical analyses included descriptive statistics, independent samples *t*-test, one-way analysis of variance, and one-way multivariate analysis of variance. Statistically significantly higher quiz scores were observed among those who viewed the infographics than those who viewed text-only medication leaflets, indicating better immediate knowledge retention of medication information. Those who viewed the infographic also had statistically significantly lower intrinsic and extraneous cognitive load, and higher germane cognitive load. These findings are consistent with the hypothesis that infographics prepared using the CTML result in better and more efficient learning. Limitations of this research include use of nonprobability sampling, examining only two medications that are commonly used in serious illness, and lack of systematic randomization. Additional research is needed to continue determining best practices for instructing and supporting IFCs in medication management.

The Effect of Medication Information Delivery Format on Cognitive Load and  
Knowledge Retention of Informal Caregivers

by  
Mary Lynn McPherson

Dissertation submitted to the Faculty of the Graduate School of the  
University of Maryland, Baltimore in partial fulfillment  
of the requirements for the degree of  
Doctor of Philosophy  
2023

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## **Dedication**

This manuscript is dedicated to my family, friends, colleagues, and classmates; without their support this journey would not have crossed the finish line. I'm particularly grateful to my husband, Jim, for his long-standing patience. Jim, I promise, no more degrees. To my daughter, Alex, my sister Andrea, and my nieces Juli and Kelsey, even though you speculated about my sanity, you were always supportive and encouraging. I know we all look forward to breathing a deep sigh of relief, most especially myself!

## **Acknowledgements**

I'd like to thank Dr. Christina Cestone, my Co-Chair. Thank you for developing this program and inviting me to join the first cohort! And thanks for introducing me to the cognitive theory of multimedia learning (where has Dr. Mayer been my whole life?).

A deep and sincere thank you to Dr. Violet Kulo, for stepping in as Co-Chair of my committee. Her editorial advice and support were indescribably valuable. I have been very touched by the remarkable depth of Dr. Kulo's sincere and genuine desire for students to succeed.

The entire class is thankful to Dr. Karen Gordes, a voice of reason both in the classroom, and otherwise. Dr. Gordes could always be counted on to be the calm in any storm! Thanks also to Dr. Hyun-Jin Jun, who did her level best to teach me statistics! I think at least the important parts stuck! I very much appreciate Dr. Andy Stanfield's expertise in design and graphics, particularly in consideration of the cognitive theory of multimedia learning. And last, thank you to Dr. Denys Lau, whose research inspired this study; I feel very fortunate to have added to the ongoing quest to assist informal caregivers of patients living with a serious illness in carrying out their medication management tasks.

Thank you all sincerely – I think it really does take a village to launch a PhD graduate!

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## CHAPTER ONE: INTRODUCTION

### Background

Patients living with a serious or life-threatening illness often have many needs which will require the assistance of family members or friends, in addition to healthcare providers. Much of what we know about caring for those with a serious illness comes from our experience with hospice care. Hospice is a holistic biopsychosocial model of care for patients living with an advanced, terminal illness, and their families. Hospice care is provided wherever a patient resides, such as a private home, an inpatient hospice unit, an assisted living facility, a nursing home facility, a homeless shelter, a prison, or other location (National Hospice and Palliative Care Organization [NHPCO], 2019). Owing to the multifaceted needs of the hospice or seriously ill patient, numerous health care providers work collaboratively to provide care. When the patient lives in a private home, the majority of patients will also require the assistance of an informal caregiver (IFC), which is defined as “a relative, spouse, partner, or friend who provides care and support to someone at home without pay” (Campiono & Zebrak, 2020, p. 2181).

Informal caregivers are asked to perform a myriad of tasks that aim to provide physical, psychological, spiritual, and emotional support to hospice patients (Lau et al., 2009). Approximately half of all Medicare recipients received hospice care prior to their death from 2016 to 2020, ranging from 47.8% to 51.6% annually (NHPCO, 2022). Non-hospice Medicare recipients in the last months or year before death very commonly also suffer with serious illness and require the assistance of unpaid family (informal) caregivers to assist with these tasks (Chi et al., 2022; Lei et al., 2021; Pereira et al., 2022). One task imposed on IFCs is managing the patient’s medications, including: procuring and maintaining an adequate inventory, selecting

which medication to administer, monitoring the patient's response to the medication, and knowing what action to take based on that response (Wilson et al., 2018).

While there are many potential barriers to effective medication management (Lau et al., 2010a), IFCs are often overwhelmed by the sheer number of tasks imposed on them, and specifically, their lack of knowledge about the medications used (Pop et al., 2022). Informal caregivers of patients with a serious illness commonly experience emotional and physical difficulties, to an even greater degree than IFC of older adults in the community who are not at the end of life (Ornstein et al., 2017). Responsibility for medication management, including knowing how a medication works, when and how to administer the medication, how to monitor the patient for medication-related side effects, and actions to take if a side effect occurs can be especially stressful for an IFC (Kelley et al., 2013).

A typical scenario is an IFC caring for an older parent who may be unconscious and nonverbal and is displaying agitated restlessness. The IFC must discern what is causing this behavior (i.e., physical discomfort, delirium, mental anguish, anxiety, or some other cause), and which medication to administer. If the IFC decides it is physical discomfort, they must select the appropriate analgesic to administer (often an opioid), prepare the appropriate dose, and administer the dose correctly. Since the patient in this scenario is unconscious, the medication would likely be a highly concentrated oral solution (which brings enormous pressure to measure an accurate dose, because an error with an opioid may be a fatal event), which would need to be instilled in the side of the mouth. After administering the medication, the IFC would need to observe the patient's response to the medication, and if an adverse effect ensues, the IFC would need to decide what to do. This could range from do nothing, call the hospice nurse, or call

emergency services. These responsibilities have been identified as a great source of stress for hospice IFCs (Look & Stone, 2018; Travis et al., 2000).

IFCs of patients with a serious illness experience significant emotional and physical difficulties in their role as medication managers. They keenly feel the burden they carry; a medication error could hasten a patient's death, or failure to treat a symptom adequately may result in a loved one's suffering. Despite 67% of hospice providers stating that ensuring proper medication management was "most important," only about 40% stated they used a prospective method to identify a warning sign of medication mismanagement, while approximately 40% stated they used a retrospective approach (Joyce & Lau, 2012).

Many IFCs feel ill-prepared for medication management, and it is incumbent on health care professionals to provide education and ensure they are competent in medication management. One common strategy is to provide a medication information leaflet to the IFC to prepare them for this role. However, designing medication information leaflets using sound educational principles, such as an infographic designed according to the cognitive theory of multimedia learning, may optimize educational impact on IFCs.

### **Theoretical Context**

This study was guided by the cognitive theory of multimedia learning (CTML), which posits that people learn better from words and pictures, than words alone (Mayer, 2021). Words may be printed or spoken text, and pictures may be static or dynamic (Mayer, 2008). The CTML is based on three foundational theories: cognitive information processing theory, schema theory, and cognitive load theory. Cognitive information processing theory describes the dynamic, rapidly shifting processes that occur simultaneously in the acquisition, processing, and storage of

new information (Schunk, 2020). Schema theory explains how data in long-term memory is organized, and categorized as schema (Winn & Snyder, 1996). Cognitive load explains the mental effort associated with processing information from working memory, to the construction of schema and storage in long-term memory. van Merriënboer and Sweller (2010) describe three types of cognitive load: intrinsic load, extraneous load, and germane load. Intrinsic load represents the task complexity, extraneous load represents instructional features that are not beneficial to learning, and germane load represents the mental effort that leads to understanding the new information. Greater understanding of these three types of cognitive load can influence educational practices.

Mayer (2021) developed 15 principles of multimedia design of learning objects that have a significant effect size on learning outcomes. These 15 principles fall into three categories: those that reduce extraneous processing (extraneous load), manage essential processing (intrinsic cognitive load), and foster generative processing (germane cognitive load). Principles that are important for this research include coherence (eliminating unnecessary words, sounds or graphics), signaling (highlighting essential words or graphics), spatial contiguity (placing essential words next to corresponding graphics), segmenting (divide learning material into user-paced segments), pre-training (teaching names, characters, definitions, abbreviations prior to the learning activity), personalization (using conversational style instead of formal style), and generative activity (providing guided generative learning activities). The CTML and the principles of multimedia design of learning objects will help address the problem identified below.

## **Statement of the Problem**

Unless an IFC has prior training as a health care professional, it is unlikely they are prepared for the medication management role. While there are currently no clinical guidelines on best practices to support IFCs in medication management for patients with a serious illness, professional caregivers of seriously ill patients often provide some level of education about medication management for the patient and IFCs. However, approaches may be highly variable and inconsistent, may not allay the concerns of IFCs, or allow mastery of expected medication management tasks. IFCs feel unprepared for the cognitive aspects of medication management (i.e., knowing how the medication works, when and how to administer the medication, how to monitor the patient for medication-related side effects, and actions to take if a side effect occurs) (Kelley et al., 2013).

In considering various options for educating IFCs about medication management, it is important to consider several variables. The educational materials should be engaging and presented at an easily comprehended grade reading level. The American Medical Association and National Institutes of Health recommend that materials written for a lay audience not exceed a sixth to eight grade reading level (Rooney et al., 2021). The essential information about the medications used should be included, but only that information. It should be a tangible learning tool that the IFC can refer to repeatedly as necessary (U.S. Department of Health and Human Services and Centers for Disease Control and Prevention, 2009). If it is a hospice patient, the nurse case manager should be able to use the learning tool in the normal flow of caring for the patient, not requiring the IFC to go outside the home for training.

Several studies on the educational value of infographics have stated that the CTML is an important design guide (Alwadei & Mohsen, 2023; Dogomeo & Aliazas, 2022; Polowsky & Steciuch, 2020), but only one of the studies mentioned operationalizing any of Mayer's principles in designing the infographic (Polowsky & Steciuch, 2020). Martin et al. (2019) compared participant preference, delayed information retention, and self-assessed cognitive load after reading infographic article summaries as compared to traditional text-only research abstracts. The problem is that the literature has not addressed the effect of medication information delivery format (infographic vs. text) on knowledge retention and cognitive load of IFCs of seriously ill patients.

### **Purpose of the Study**

The purpose of this quantitative, experimental study was to investigate the impact of medication information delivery format on immediate retention of medication information and cognitive load of IFCs of seriously ill patients, including those receiving hospice or palliative care. The independent variable was the format of the medication information leaflet prepared either as an infographic designed according to the tenets of the cognitive theory of multimedia learning (Mayer, 2021) or a more customary text medication educational leaflet. Dependent variables were immediate knowledge retention scores as measured by a quiz, and cognitive load, including intrinsic, extraneous, and germane cognitive load.

## Research Questions and Hypotheses

Research questions and hypotheses are as follows:

**RQ1:** Is there a statistically significant difference in knowledge retention as demonstrated by a quiz score, between participants after viewing a medication informational leaflet prepared as an infographic and participants viewing a text passage written at the same reading level?

**H<sub>0</sub>:** There is no statistically significant difference in knowledge retention as demonstrated by a quiz score, between participants after viewing a medication informational leaflet prepared as an infographic and participants viewing a text passage written at the same reading level.

**H<sub>1</sub>:** There is a statistically significant difference in knowledge retention as demonstrated by a quiz score, between participants after viewing a medication informational leaflet prepared as an infographic and participants viewing a text passage written at the same reading level.

**RQ2:** Is there a statistically significant difference in cognitive load (intrinsic, extraneous, and/or germane), between participants after viewing a medication informational leaflet prepared as an infographic and participants after viewing a text passage written at the same reading level?

**H<sub>0</sub>:** There is no statistically significant difference in cognitive load (intrinsic, extraneous, and/or germane), between participants after viewing a medication informational leaflet prepared as an infographic and participants after viewing a text passage written at the same reading level.

**H<sub>1</sub>:** There is a statistically significant difference in cognitive load (intrinsic, extraneous, and/or germane), between participants after viewing a medication informational leaflet prepared as an infographic and participants after viewing a text passage written at the same reading level.

## **Significance of the Study**

Findings from this study have significant implications for educating IFCs and preparing them for their role in medication management. The current methods for educating IFCs are not adequate or may be lacking entirely, and IFCs continue to feel ill prepared to manage medications. While research on the use of infographics has been compelling in that learners “like” infographics, assessment of knowledge recall and comprehensive has been mixed (Buljan et al., 2018; Caron et al., 2018; Damman et al., 2018; Dowling et al., 2019; Egan et al., 2021; Falk, 2016; Jaleniauskiene & Kasperuniene, 2023; Jones et al., 2019; Ozdamli & Ozdal, 2018). This study is important because the infographics were designed with strict adherence to the principles of the CTML and resulted in a favorable effect on knowledge retention. This research supports the utility of the CTML and informs preferred educational practices when working with IFCs.

The study will contribute to the existing literature in how to best design and evaluate educational tools for IFCs of seriously ill patients regarding medication management, particularly educational interventions that can be conveniently incorporated into the usual flow of patient care. Particular attention was paid to the actual design of the infographics, following the theory of the CTML; overwhelmingly the literature to date evaluating the educational impact of infographics did not base the design on a theoretical model. However, in recent years, several studies have stated their research incorporated the CTML as an important design element, but with one exception there was no explanation of how the CTML design elements were operationalized (Polowsky & Steciuch, 2020).

Martin et al., (2019) acknowledge the importance of cognitive load theory in designing infographics, but not the CTML specifically. While they did attempt to estimate cognitive load differences between an infographic and a text equivalent, they used a cognitive load assessment scale that has been criticized (Ayres, 2018; Paas, 1992). This research incorporated the design principles of the CTML in creating infographics, and used a validated instrument to assess cognitive load which was able to distinguish between intrinsic, extraneous, and germane cognitive load. This demonstrates that infographics, when designed as described above, not only are preferred by learners, but also result in enhanced knowledge retention, reduced intrinsic and extraneous load, and increased germane cognitive load.

### **Organization of Chapters**

Chapter 1 of the study presents the introduction including the study background, research problem, purpose of the study, research questions and hypotheses, and significance of the study. Chapter 2 is a review of relevant literature including the tasks of IFC, particularly as they pertain to medication management. Additionally, literature on cognitive load and the cognitive theory of multimedia learning will be discussed. Lastly, literature on the use of infographics to enhance learning will be presented. Chapter 3 will present the methodology used in the study including research design, identification of independent and dependent variables, the research hypotheses, a description of the study sample, instrumentation, procedures, data collection, and statistical analysis. Chapter 4 will present the results of the study. Chapter 5 will discuss and interpret the results, present limitations of the study, conclusions as well as recommendations for practice and future research.

## **CHAPTER TWO: LITERATURE REVIEW**

This chapter provides an overview of the role of the IFC in caring for a seriously ill person, particularly the responsibilities associated with medication management. A review of the challenges, fears, and concerns held by IFCs in their role as medication manager will be presented, as well as what strategies have been used to prepare IFC for this role, and available outcome data. One useful strategy to better prepare IFC as medication managers is to provide educational materials that present a lower mental effort, hopefully increasing comprehension and retention. This chapter will address the cognitive theory of multimedia learning (CTML), its foundational theories and principles, and how this learning theory has been applied to the development of an infographic intervention. Lastly, literature on outcomes associated with the use of infographics will be presented.

### **Serious Illness and Hospice Care**

In the United States, about 45 million people live with serious illness, defined as a medical condition that has a high risk of mortality, and has a negative effect on the patient's functional status and/or quality of life, or places a high level of strain on their informal caregivers (Bell et al., 2019). Serious illness includes examples such as cancer, dementia, advanced organ disease (hepatic, renal, cardiac, etc.), multiple chronic diseases, or any condition experienced at the end of life (Hudson et al., 2020). Much of what we have learned about the burden imposed on IFCs caring for these patient populations comes from the hospice population.

Hospice is a model of care for patients living with a serious, advanced illness. It is described by the National Hospice and Palliative Care Organization (2022) as follows:

Considered to be the model for quality, compassionate care for people facing a serious or life-limiting illness or injury, hospice care involves a team-oriented approach to expert medical care, pain management, and emotional and spiritual support expressly tailored to the patient's needs and wishes. Support is provided to the patient's loved ones as well.

Due to the multidimensional aspects of patient and family needs, hospice care is provided by an interprofessional team consisting of physicians, nurses, social workers, chaplains, pharmacists, home health aides, and more. Another important member of the team is someone to assist with care of the patient, usually a friend or family member. These friends or family members are called on to provide a myriad of tasks for the patient, in addition to serving as part of the unit of care themselves. Because these individuals are unpaid, and usually not trained in health care delivery, they are referred to as informal caregivers.

### **Informal Caregivers in Hospice Care**

Hospice care is provided at the patient's place of residence, whether it is a residential hospice facility, acute care hospice inpatient unit, long-term care facility, assisted living, domiciliary care, a private home, or some other location. When the patient lives in an environment where there are no professional caregivers present (such as nurses, and aides), IFCs are asked to participate in the care of the patient.

### ***Definition and Prevalence of IFC***

An IFC is defined as "a relative, spouse, partner, or friend who provides care and support to someone at home without pay" (Campion & Zebrak, 2020, p. 2181). According to the National Alliance for Caregiving and American Association of Retired Persons (AARP) (NAC, 2020), as of 2020 approximately 53 million adults in the US served as informal caregivers to a

child or adult in the preceding 12 months, which is an 18.2% increase since 2015. Almost 48 million had served as a caregiver to an adult, with over 42 million serving as caregiver to adults over the age of 50 (NAC, 2020, Figure 2.1).

**Figure 2.1**

*Prevalence of Caregiving by Age of Care Recipient, Comparing 2020 to 2015*

	2020 Prevalence	Estimated Number of US Adults Who Are Caregivers	2015 Prevalence	Estimated Number of US Adults Who Are Caregivers
Overall	21.3%*	53.0 million	18.2%	43.5 million
Caregivers of recipients ages 0-17	5.7%*	14.1 million	4.3%	10.2 million
Caregivers of recipients ages 18+	19.2%*	47.9 million	4.3%	39.8 million
Caregivers of recipients ages 18-49	2.5%	6.1 million	2.3%	5.6 million
Caregivers of recipients ages 50+	16.8%*	41.8 million	14.3%	34.2 million

From *The National Alliance for Caregiving*, 2020 (<https://www.caregiving.org/>). Reprinted with permission.

Respondents of the 2020 survey reported greater health and functional needs of both caregivers and patients since the last survey. Not only do patients have a greater number of comorbidities as compared to previous years surveys, but the medical complexity of care is also greater. According to the 2020 survey, 99% of informal caregivers assisted patients with Instrumental Activities of Daily Living (IADL), and almost 60% participated in medical/nursing tasks, including medication management.

Serving as an informal caregiver exacts a toll in terms of loss of personal time, finances, and personal well-being. IFCs report this is a stressful role with information, resources, benefits,

programs, and sufficient support lacking (Smucker et al., 2014; Solli & Hvalvik, 2019). Gardiner et al. (2020) summarize evidence that suggests IFC contributions represent up to 70% of all health care costs. They further state that costs can be categorized into three areas including work related costs, carer time costs, and out of pocket costs (Gardiner et al., 2020).

A RAND corporation study conducted in 2014 estimated that the “price tag” for informal caregiving was approximately \$522 billion a year (Chari et al., 2015). The authors speculated that replacing IFC with paid unskilled workers would cost over \$220 billion/year, while skilled nursing care would cost almost \$650 billion/year. Using the 18.2% growth in informal caregiving as reported by the National Alliance for Caregiving (NAC, 2020) from 2015 to 2020, the price tag for informal caregiving in 2020 would likely exceed \$600 billion/year, \$260 billion/year if replaced by unskilled paid caregivers, or \$768 billion/year if replaced by skilled nursing care. This data was confirmed by Coe et al. (2018) who concluded that informal care cost \$277 billion in 2011 and is higher with greater patient functional impairment.

Drawing from the 2011 National Health and Aging Trends Study (NHATS) and its linked National Study of Caregiving (NSOC), Ornstein et al. (2017) compared characteristics of older adults and their caregivers, distinguishing between those patients at the end of life (within one year of death) and those not at the end of life. Patients at the end of life were older, more likely to be female, experienced substantially greater self-rated poor health, functional impairment, and greater need for assistance. The informal caregivers provided a greater number of hours of care per week (22.9 hours/week for end-of-life patients, vs. 16.1 hours/week for other patients), and significantly greater assistance with a wide range of personal care activities, and activities of daily living. IFC of patients within a year of death were statistically more likely to be called on

to assist with medication management and handling medical tasks (56.7% and 14.7%, respectively) as compared to IFC of patients not within a year of death (48.3% and 9.9%, respectively). The IFC of patients at the end of life claimed statistically greater exhaustion, lack of personal time, and lack of routine. End of life IFCs were more likely to experience emotional difficulties (50.7% vs. 43.2%) and physical difficulties (34.9% vs. 21.3%). The caregiving burden is greater when the patient is near the end of life, and IFC in this population consequently report a greater personal toll.

### ***Caregiving Tasks in Hospice Care Including Medication Management***

Informal caregivers, in general, take on a variety of roles including providing and coordinating emotional, practical and health service matters (Adejoh et al., 2021). This includes assistance with activities of daily living, personal care, laundry, nutrition support, assistance with medications and medical interventions, and emotional support of the patient. Adejoh et al. (2021) report that providing this range of services exacts a personal, social, and financial cost on IFC.

Early literature evaluating medication management tasks of IFC caring for older adults reveals themes such as medication scheduling logistics, administrative procedures, and safety issues (Travis et al., 2000). Additional tasks include assuring an adequate supply of medications, administering medications, making clinical judgements related to medications, and communication with the health care team (Smith et al., 2003). Look and Stone (2018) conducted focus group interviews with 29 IFCs of older adults and identified two common themes regarding medication management tasks. These included direct activities requiring physical handling of medications (acquiring medications, organizing medications such as pill boxes, assisting with medication administration) and cognitive activities (such as organizing and

tracking medications, evaluating the patient's response to drug therapy, and making treatment decisions).

Lau et al. (2009) and Wilson et al. (2018) provide a comprehensive categorical summary of medication management tasks that IFCs of patients with advanced illness are asked to carry out. Lau et al. (2009) conducted semi-structured interviews with 22 hospice providers (nurses, physicians, and social workers), and 23 dyads of family IFCs and elderly hospice patients. Lau et al. (2009) defined effective medication management in hospice as:

...caregivers' ability to effectively relieve symptoms with pharmacological interventions by successfully utilizing skills related to teamwork (coordinate with hospice providers and with other family or hired caregivers), organization (acquire, store, track, and discard medications), symptom knowledge (recognize and interpret common symptoms), medication knowledge (understand the basics of pharmacology and medication administration), and personhood (understand and respond to patient's needs). (p. 79)

Wilson et al. (2018) conducted a literature review of 15 identified articles that explored IFCs experience and thoughts on medication management for a patient dying at home. The authors identified five themes: administration, organizational skills, empowerment, relationships, and support. These themes encompass a spectrum of skills that include elements of good communication, medication acquisition, and physically administering the medication. Cognitive skills and clinical judgement are also key, including knowing when to administer a medication, which medication to administer, how to monitor the patient's response to the medication, and the appropriate course of action should an untoward event occur. These tasks range in complexity,

leading to an increased risk of medication errors and therapeutic misadventures (Lau et al., 2009).

### ***Informal Caregiver Challenges and Fears in Hospice and Serious Illness Medication Management***

Many researchers have provided significant insight into IFC concerns regarding medication management when caring for patients with a serious illness (Chi & Demiris, 2017; Chi et al., 2018; Chi et al., 2022; Chi et al., 2023; Kelley et al., 2013; Oliver et al., 2013). The authors specifically queried challenges in medication management regarding pain control, but the findings are largely applicable to the management of all medications in serious illness. They identified six main themes including caregiver-centric issues, caregiver medication skills and knowledge issues, end-of-life symptom knowledge issues, communication and teamwork issues, organizational skill issues, and patient-centric issues.

Caregiver-centric issues refer to challenges the IFC faces in the general assessment and management of the patient's pain. Medication skills and knowledge issues refers to more specific skills associated with assessing a complaint of pain, knowing which medication to select for administration, physically administering a medication, monitoring the patient's response to the medication, and action steps based on this monitoring. End-of-life symptom management is closely related to medication skills and knowledge and refers to specifically assessing and differentiating symptoms associated with a terminal illness. Communication and teamwork issues describe communication challenges between the IFC and the patient, hired help, hospice professionals, other health care providers, and family members. Organizational skill issues deal with tracking and safety issues in medication management. Lastly, patient-centric issues include

variables such as the patient's beliefs and values and ability to report pain, which influence medication administration. The major theme of *caregiver's medication skills and knowledge* most closely aligns with this research (Kelley et al., 2013). Specifically, this skill set includes knowing how the medication works, when and how to administer the medication, how to monitor the patient for medication-related side effects, and actions to take if a side effect occurs.

Li and Look (2022) investigated the relationship between IFC characteristics and their difficulty in managing medications for patients with dementia. The IFCs found that keeping track of medications, and administering injections were particularly problematic. Pop et al. (2022) reported that IFCs of cancer and non-cancer patients receiving palliative care found that the burden of medication management was actually higher with non-cancer patients, likely due to the higher number of medications prescribed as compared to cancer patients.

Informal caregivers often feel frustrated, overwhelmed, and often frightened about their role in medication management. Knowing this, health care providers or systems may provide either formal, or more commonly, informal education on medication management to IFC. Several of the themes identified above are amenable to education, particularly providing information on how to assess pain or some other symptom, which medication to give, how to give the medication, how to monitor the patient's response to therapy, and action steps to take in the face of an adverse response to drug therapy.

Several caregiver-specific attributes may influence the burden imposed with medication management. For example, Lau et al. (2010b) found the following factors to impede the IFC's ability to manage medications of home hospice patients: IFC's negative emotional state (grief and fatigue), cognitive or physical impairments, low literacy level, competing responsibilities

(employment, housekeeping, responsibility for other dependents), patient's negative emotional state, complex medication needs, close relations that may cloud caregivers' judgment, and poor communication/relations among caregivers and family conflicts. Age is also inversely correlated to medication literacy, or "the specific ability to safely access and understand the information available concerning medication, and to act accordingly" (Plaza-Zamora et al., 2020, p. 1). They also disclosed an inverse correlation between highest level of academic achievement and medication literacy. Bosch-Lenders et al. (2016) also found an inverse correlation between age and the ability to identify the indication for a medication, and age, as well as male gender.

Semere et al. (2019) described characteristics and experiences of IFC with limited English proficiency, who have assumed responsibility for the care of an older adult at home. Ninety percent of IFC surveyed performed three or more caregiving roles for the patient (including medical decisions and care), and 40% reported experiencing moderate to high levels of stress. Sanderson (2020) found that language asymmetry was responsible for IFC stress over and above stresses experienced by an English-speaking caregiver. Wittenberg-Lyles et al. (2013) evaluated the impact of oral literacy in communication with hospice IFC, concluding that IFC understanding and comfort with administering pain medications and IFC quality of life were negatively correlated with dialogue pace. The Flesch reading level (grade 4.2) was also statistically correlated with IFC comfort with, and understanding of pain management.

Noureldin and Plake (2017) found factors that were significantly associated with the need to have an informal caregiver to manage the medications of older adults. The authors identified variables associated with two or more medication management activities, which speaks to increased complexity in patient care. Variables that were more likely to predict need for an IFC

to perform medication management included the IFC being female, a spouse/partner of the patient, employed outside the home, assisting with the patient's instrumental activities of daily living, and caring for an older patient, Hispanic patient, a patient with lung disease or dementia, or patient has a high school degree or less. In a different study, variables of IFC who were younger and the adult child of the patient who provided medication management for older adults predicted IFC medication information-seeking behavior (Noureldin et al., 2017).

### ***Preparing IFC for their Role in Medication Management***

Education is a key aspect of preparing informal caregivers for their role in managing medications for a seriously ill patient. There are currently no clinical guidelines on best practices to support IFC in medication management in seriously ill or hospice patients. Neither the National Consensus Project for Quality Palliative Care (2018), nor The Joint Commission National Patient Safety Goals (2022) provide any guidance. Approaches to educating and supporting IFC in the medication management role are therefore left to individual hospice programs to design and implement.

Joyce and Lau (2012) surveyed 98 hospice providers, of whom 67% rated ensuring proper medication management as “most important.” Participants described using prospective and retrospective approaches to identifying medication management problems in the home. Forty-two percent of respondents stated they used at least one prospective approach to problem identification, whereas 38% used a retrospective approach, recognizing the problem when a medication problem or error occurred. The authors concluded that reliance on retrospective signs of therapeutic misadventure is suboptimal. Prospective approaches, while preferable, were found to be an inconsistent approach among those interviewed.

Participants identified three approaches they felt would be useful to support IFC in the medication management role: teaching to increase knowledge, supporting or stream-lining medication management processes, and providing counseling to overcome attitudinal barriers (Joyce & Lau, 2012). Half of respondents reported using one of the three strategies, about a third reported using two of the three strategies, and only 6% reported using all three strategies. Almost half of the respondents stated they would benefit “to a great extent” from additional resources to better support IFC in medication management. The same research group (Joyce et al., 2014) surveyed 120 hospice IFC about the degree of support they received in the medication management role. Almost 40% of respondents stated they had no additional support with managing medications, about 20% had formal support (e.g., a paid caregiver), 30% had informal support (e.g., another family member), and the remainder had both.

As mentioned earlier, Lau et al. (2009) proposed a theoretical construct of family caregiver skills in effective medication management which included teamwork, organization, symptom knowledge, medication knowledge, and personhood. Tjia et al. (2015) recorded eighteen visits by nurses to home hospice patients and determined to what extent each element of the construct proposed by Lau et al. (2009) was addressed during each visit. Results showed that an average of four medications were discussed at each visit. Attention to each element of the model from Lau et al. (2009) were teamwork (11/18 visits), organization and personhood (10/18 visits), symptom management (12/18 visits) and medication knowledge (15/18 visits). No attempt was made to assess IFC satisfaction or skill in medication management.

Latter et al. (2016) systematically reviewed studies of interventions to help IFC manage medications in advanced cancer patients. Eight studies were identified, and all were thought to

have significant methodological limitations. Study designs included single group pre-test/post-test design and randomized controlled trials. Interventions were one to three face-to-face educational sessions, usually with accompanying written or other resources. None of the eight studies used the formal caregivers assigned to the patient's case (e.g., the nurse case manager, social workers, etc.). The majority of studies reported improvement in IFC knowledge or self-efficacy in medication management; there was no effect on patient pain control or adverse effects noted. The authors pointed out that only one study referenced a theoretical framework that supported their intervention.

A variety of strategies have been tried to maximize medication management by IFC in various patient populations with a serious illness. Lingler et al. (2016) home- and telephone-based educational sessions delivered by a nurse or social worker addressing the basics of medication management. The results showed an improvement in medication management skills in both the intervention and control group. Medication management interventions for the IFCs of patients with dementia have included accessing the internet for medication management information (Horne, et al., 2018), hospital discharge interventions, post-discharge multidisciplinary team intervention, and discharge summary documentation (Sawan, et al., 2021) with mixed results. Similarly, caregiver-based interventions evaluated in a systematic review also showed mixed outcomes regarding IFC medication knowledge and self-efficacy, with mixed results as well (Wagle et al., 2018).

The study by Donovan et al. (2007) was based on the representational approach to patient education which is gaining an understanding of the patient's baseline knowledge before providing additional information. Results were mixed, with about half the studies showing an

improvement in one of their measures, although data were not provided in all cases. None of the studies were informed by psychosocial theory or educational theory. Latter et al. (2016) concluded that educational interventions, as illustrated in these eight studies, have the potential to help IFC in medication management. The authors stated that further research is needed to best determine how to prepare IFC for the medication management role. It seems unlikely that all hospices will be able to provide a separate education team; rather, best practice would be educational resources and techniques that the hospice could provide.

### **Theoretical Framework**

This study was guided by the cognitive theory of multimedia learning (CTML). This section will first present a brief overview of the CTML and review the foundational theories that support the CTML (cognitive information processing theory, schema theory, and cognitive load theory), including how to maximize their effectiveness. Following this discussion, the last section will discuss how the components of cognitive information processing theory, schema theory, and cognitive load therapy are specifically operationalized in the CTML including Mayer's (2021) design principles.

#### **Cognitive Theory of Multimedia Learning**

Learning is described as the selection, organization and integration of incoming material with existing knowledge from long-term memory (Mayer, 2008). Mayer authored extensive research in developing and testing the principles of a cognitive theory of multimedia learning (CTML). Mayer (2014) defines multimedia, multimedia learning, and multimedia instruction as follows:

- “Multimedia – presenting words (such as printed text or spoken text) and pictures (such as illustrations, photos, animation, or video)
- Multimedia learning – building mental representations from words and pictures
- Multimedia instruction – presenting words and pictures that are intended to promote learning” (p. 2)

Research suggests that people learn better from words and pictures than from words alone; this premise is the backbone of CTML (Mayer, 2021). Words may be printed or spoken text, and pictures may be static or dynamic (Mayer, 2008).

### **Foundational Theories**

The CTML is one example of a cognitivist learning theory. Cognitivist learning theory emerged in the mid-20<sup>th</sup> century, challenging the behaviorist hard line of stimulus and response principles of behaviorism to explain learning (Harasim, 2017). Cognitive learning theorists brought “cognition” to the learning process, specifically, “cognitive theories of learning focus on how knowledge is acquired, constructed, and represented in the mind and subsequently remembered” (Kay & Kibble, 2016, p. 19). Cognitive learning theory is an umbrella, or macro-theory, encompassing many concepts, theorists, and theories. Theorists include Piaget, Tolman, Kohler, Miller, Neisser, Chomsky, Gagné, Tolman, Kohler, Krechevsky, Anderson and Sweller to name a few (Harasim, 2017; Michela, 1970). Three learning theories are foundational to the cognitive theory of learning: cognitive information processing, schema theory, and cognitive load.

## *Cognitive Information Processing Theory*

Schunk (2020) provides an excellent overview of the contemporary information processing model. This model depicts dynamic, rapidly shifting processes occurring simultaneously (as opposed to sequentially). A variety of environmental stimuli bombard us every day, all day long. These stimuli are initially coded in the sensory memory, however the vast majority (as much as 99%) are discarded within a second or two (Schunk, 2020). Inputs that are retained are transformed into meaningful perceptions (that make sense) and transferred to the working memory. Kay and Kibble (2016) liken the working memory to your mind's desktop; only so many bits of information can be processed at one time. Miller (1956), a cognitive psychologist, published seminal work on how many objects a person can hold in short-term (working) memory, and it is approximately five to seven (i.e., seven for digits, six for letters, five for words).

Baddeley and Hitch (1974) proposed that working memory is composed of two subsystems: a visuo-spatial sketch pad processor and a phonological loop processor, tied to central executive function. The visuo-spatial sketch pad processor receives and manipulates visual images, while the phonological loop stores and interprets verbal information (Baddeley, 1992). Unfortunately, these dual channels are capacity-limited, meaning there is a saturation point and no additional information can be processed and stored in long-term memory, which is thought to have an unlimited capacity (Kirschner, 2002). Working memory can hold about 2 seconds of sound (Baddeley & Hitch, 1974). Whether it is a letter, number, word, or sound, if not processed quickly from working memory, those pieces of information will be lost.

Baddeley (2010) later added a fourth component known as the episodic buffer. The episodic buffer can serve as a temporary store for the components of working memory and can interact with information from long-term memory and perception. This is also a capacity-limited component, assumed to have a capacity of approximately four chunks of episodes. For those pieces of information that receive enough attention, they are integrated with knowledge already in the long-term memory. This process is known as consolidation. Consolidation “occurs by forming or adapting existing neural networks or by strengthening existing ones” (Schunk, 2020, p. 181). The new “mental representations” that transfer to long-term memory are not particularly stable; consolidation is the process of the brain reorganizing and stabilizing this information and memories (Brown et al., 2014, p. 73). Long-term memory is thought to be a repository of all information stored by an individual throughout their life and theoretically should be retrievable (Lovell, 2020). However, it is a familiar sensation of having forgotten some fact or memory, so perhaps this information becomes less accessible over time if not stored appropriately or accessed frequently enough.

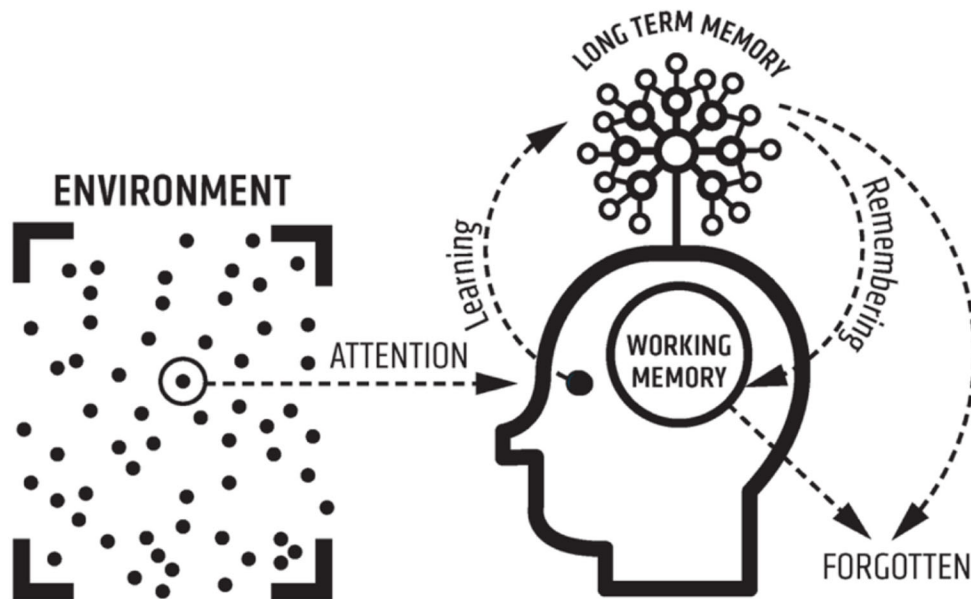
### ***Schema Theory***

Bartlett (1932) introduced schema theory, and it has been clarified and refined by other theorists over the years. Harasim (2017) explains that “the concept of schema in cognitivist learning theory is related to mental representation and structural knowledge...learning is easier if new subject matter is compared to existing knowledge and is structured or representational” (p. 49). Schema theory posits that all data in long-term memory is organized, categorized, and stored in schema. Schemata have relationships with other schema, which helps us to recognize and remember objects or events (Jonassen et al., 1993).

Winn and Snyder (1996) describe common features of popular descriptions of schema as follows: schema supports memory structure, schema is more abstract than reality, schema are linked together concepts, schema are dynamic structures, and schemas provide context for interpreting new information and provide structure to contain it. Schunk (2020) provides several examples of how instruction can be tailored to foster schema formation including laboratory procedures, understanding stories, and re-assessing understanding, such as self-quizzing. These processes are depicted in Figure 2.2 (Lovell, 2020), illustrating how humans bring new information from the environment into our working memory, consider that new information and either move it to long-term memory, or it is forgotten.

**Figure 2.2**

*Learning and Memory*



From Sweller's *Cognitive Load Theory in Action* (p. 19), by O. Lovell, 2020, John Catt

Educational Limited (<https://www.johncattbookshop.com/sweller-s-cognitive-load-theory-in-action>). Copyright 2020 by Oliver Lovell. Reprinted with permission.

## ***Cognitive Load Theory***

The ease with which individuals process information in working memory in the construction of schema and storage in long-term memory is best described by three types of cognitive load. Specifically, as described by Young et al. (2014), there are three types of cognitive load: 1) Intrinsic load (load associated with the task); 2) Extraneous (extrinsic) load (load not essential to the task), and 3) Germane load (load imposed by the learner's deliberate use of cognitive strategies to reorganize information to make it suitable for storage in long-term memory [i.e., to learn]).

**Intrinsic Load.** Intrinsic load is related to the task itself, and how much mental effort the learner must expend to construct a schema. The more complex the new information is, the higher the intrinsic load. The intrinsic load depends on several variables including the proficiency of the learner, the number of pieces or elements of information to be incorporated into the schema, and the degree to which the elements of information related to each other (the more dissimilar, the higher the intrinsic load) (Young et al., 2014).

**Extraneous (Extrinsic) Load.** Extraneous load is influenced by instructional processes and the learning environment. For example, very busy slides with unnecessary information impose a high extraneous load because learners' attention is split searching for what is important, while being distracted by the unnecessary or irrelevant information (De Koning et al., 2009). Failure to link conceptual elements for learners, or link to prior learning may also increase extraneous load. A chaotic environment or background noise can impose an additional burden. These variables add to the learner's work of learning yet are not necessary for forming schemata or learning (Mancinetti et al., 2019; van Merriënboer & Sweller, 2010; Young et al., 2014).

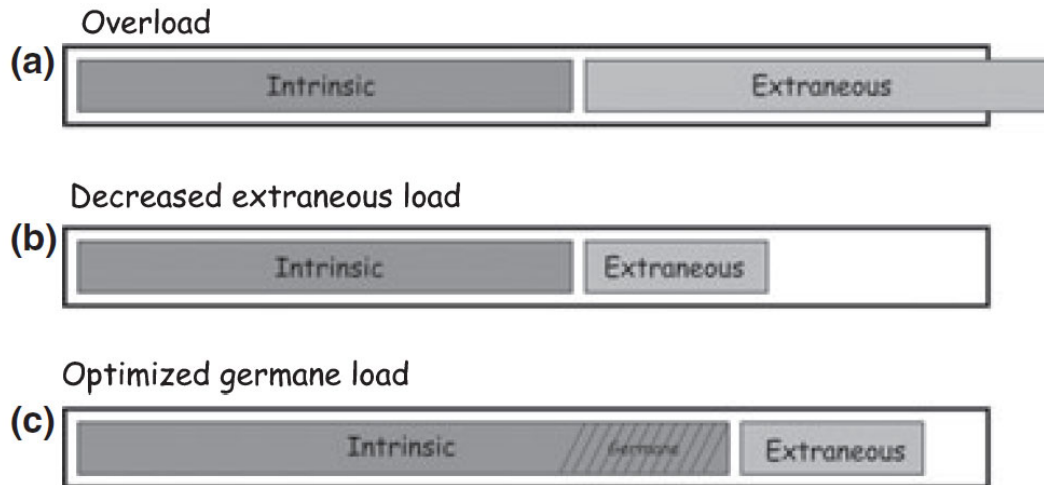
**Germane Load.** Germane cognitive load refers to processing new information in a meaningful fashion (Mancinetti et al., 2019), such as the formation of schemata and automation of stored information. Young et al. (2014) describe germane load as “the learner’s level of concentration devoted to learning” (as opposed to performing the task) (p. 375). Van Merriënboer and Sweller (2010) describe germane load as the “working memory resources used to deal with intrinsic cognitive load,” (p. 88) which results in learning. Information must be processed in a meaningful fashion for learning to occur. For example, Costley and Lange (2017) sought to determine if using a variety of auditory and visual media enhanced germane load in an online lecture. Their results showed a positive correlation between combining various forms of both auditory and visual media, and germane cognitive load.

Cognitive load theory assumes that intrinsic and extrinsic cognitive loads are additive (van Merriënboer & Sweller, 2010). In other words, if the intrinsic load is low (e.g., an easy task) and if the extrinsic load is a bit larger, it may not have a significant effect on learning. When the intrinsic load is high, such as wrestling with complex, new material, there are fewer cognitive resources available for dealing with extrinsic load. For example, if an infographic designed according to the CTML lowers the intrinsic load, an IFC will have additional cognitive resources free to comprehend and process the medication information. Thus, learning is a balancing act between intrinsic cognitive load (in which germane cognitive load is subsumed) and extrinsic cognitive load with the goals of managing intrinsic cognitive load, optimizing/minimizing extraneous load, and promoting germane load (Figure 2.3).

**Figure 2.3**

*The Additive Nature of Intrinsic and Extraneous Overload*

The



additive nature of intrinsic and extraneous load: (a) overload; (b) preventing overload by decreasing extraneous load, and (c) optimizing germane load by increasing intrinsic load. From “Cognitive load theory in health professional education: Design principles and strategies,” by J. J. G. van Merriënboer and J. Sweller, 2010, *Medical Education*, 44, p. 88. <https://doi.org/10.1111/j.1365-2923.2009.03498.x>. Blackwell Publishing Ltd. Reprinted with permission.

There has been significant interest in measuring cognitive load and its components for a variety of reasons, including as a means to assess the effectiveness of interventions that aim to optimize cognitive load. Paas et al. (2008) globally describe four empirical approaches to assessing cognitive load: “1). Subjective data using rating scales, 2. Performance data using primary and secondary task techniques, 3. Physiological data using physiological techniques, and 4. Data aligning physiological measures with the visible learning process markers (i.e., mouse clicks, movement between screens, etc.)” (p. 15).

### ***Maximizing Information Processing, Schema Formation, and Cognitive Load***

Cognitive theorists have conducted research in determining best practices for teaching and studying to maximize meaningful learning. Mayer (2012) explains that “meaningful learning occurs when people engage in appropriate cognitive processing during learning, including selecting relevant information, organizing it into coherent mental representations, and integrating representations with each other and with relevant knowledge activated from long-term memory” (p. 89). Better understanding of information processing principles has resulted in the development of instructional applications that lead to enhanced learning; specifically, these include advanced organizers, conditions of learning, and cognitive load (Schunk, 2020).

**Maximizing Information Processing.** There are two proposed mechanisms for improving working memory: 1) enhancing working memory capacity, and 2) enhancing efficiency using the working memory capacity available (von Bastian & Oberauer, 2014). Outcomes from interventions that aim to enhance working memory by addressing one of these two strategies have been mixed, and highly variable (von Bastian & Oberauer, 2014; Melby-Lervåg & Hulme, 2013; Carretti et al., 2007). Trainee variables such as age, genetic predisposition, inherent cognitive ability or deficits, personality traits, and motivation can influence the magnitude and outcome of knowledge transfer assessments (von Bastian & Oberauer, 2014). For example, 43 university students in Italy were recruited for an experiment to determine the impact of working memory training by using mnemonics (Di Santo et al., 2020). Responding to a series of five tests, the participants who had received training in using mnemonics showed statistically significant better performance. However, this was likely a fairly

homogeneous population with an above-average literacy level and lower odds of cognitive impairment.

**Maximizing Schema Formation.** Rumelhart and Norman (1978, as cited in Neumann and Kopcha, 2018) suggest schemata develop through three processes of accretion (a gradual process adding daily experiences to new concepts), tuning (changes in how schemata organize information), and restricting (formation of new schema to interpret new information). The majority of instructional design and technology has focused on the strategies of imagery and concept mapping as a way to foster the development of schema (Neumann & Kopcha, 2018). Research in imagery has shown that images and text can be jointly encoded, and this enhances student learning (Abel & Kulhavy, 1989). This is illustrative of the two subsystems of the working memory working in tandem (combining images and text to improve learning). Neumann and Kopcha (2018) provide some evidence of benefit to imagery, but they state that learners' prior knowledge may affect the benefits of imagery, and design principles consistent with CTML must be adhered to.

Concept mapping has been shown to be beneficial in helping learners externalize prior knowledge while organizing new concepts and relationships (Neumann & Kopcha, 2018). van Merriënboer and Sweller (2010) explain that schemas can be “constructed during the problem-solving process by bringing elements together (i.e., chunking), by incorporating new elements in schemas already available in long-term memory, or, more commonly, by obtaining already schematized information from other people” (p. 87).

**Maximizing Cognitive Load.** van Merriënboer and Sweller (2010) provide a series of design principles and strategies recommended by cognitive load theory that aim to decrease extraneous load, manage intrinsic load, and optimize germane load (Figure 2.4).

**Figure 2.4**

*Design Principles and Strategies Recommended by Cognitive Load Theory*

Design guideline	Description	Illustration
<i>Decreasing extraneous load</i>		
Goal-free principle	Replace conventional tasks with goal-free tasks that provide learners with a non-specific goal	Ask students to 'Please come up with as many illnesses as possible that could be related to the observed symptoms', rather than asking 'Which illness is indicated by the symptoms of this patient?'
Worked example principle	Replace conventional tasks with worked examples that provide a full solution learners must carefully study	Let students criticise a ready-made treatment plan, rather than having them independently generate such a plan
Completion principle	Replace conventional tasks with completion tasks that provide a partial solution learners must finish	Let medical interns closely observe a surgical operation and only perform part of it, rather than having them perform the whole operation independently
Split attention principle	Replace multiple sources of information, distributed either in space (spatial split attention) or time (temporal split attention), with one integrated source of information	Provide students with instructions for operating a piece of medical equipment just in time, precisely when they need it, rather than providing them with the information beforehand
Modality principle	Replace a written explanatory text and another source of visual information (unimodal) with a <i>spoken</i> explanatory text and the visual source of information (multimodal)	Give students spoken explanations when they study a computer animation of the working of the digestive tract, rather than giving them written explanations on screen
Redundancy principle	Replace multiple sources of information that are self-contained (i.e. they can be understood on their own) with one source of information	When providing learners with a diagram of the flow of blood in the heart, lungs and body, do not include a verbal description of the flow
<i>Managing intrinsic load</i>		
Simple-to-complex strategy	Replace a series of conventional tasks with tasks that first present only isolated elements (low element interactivity) and gradually work up to the tasks in their full complexity	Give students tasks that require them to apply the basic physical principles of hydrodynamics, such as pressure-volume and pressure-flow relationships, before giving them tasks that require them to apply a full model of how the blood flows through the circulatory system
Low- to high-fidelity strategy	Replace a series of conventional tasks with tasks that are first performed in a low-fidelity environment (decreased element interactivity), and then in increasingly higher-fidelity environments	When teaching students medical diagnosis, start with textual case descriptions, continue with computer-simulated patients or patients played by peers, go on to simulated patients played by actors, and end with real patients in an internship in hospital
<i>Optimising Germane load</i>		
Variability principle	Replace a series of tasks with similar surface features with a series of tasks that differ from one another on all dimensions on which tasks differ in the real world	When describing a particular clinical symptom, illustrate it using patients of different sex, age, physique, medical history etc.
Contextual interference principle	Replace a series of task variants with low contextual interference with a series with high contextual interference	If students practise different variants of a particular surgical task, order these variants in a random rather than a blocked order
Self-explanation principle	Replace separate worked examples or completion tasks with enriched ones containing <i>prompts</i> , asking learners to self-explain the given information	For students learning to diagnose malfunctions in the human cardiovascular system, present an animation of how the heart works and provide prompts that ask them to self-explain the underlying mechanisms

Figure 2.4 continued on next page

Design guideline	Description	Illustration
<i>Dealing with the expertise reversal effect</i>		
Completion strategy	Replace a uniform series of conventional tasks with a series of, in order, worked examples, completion tasks for which learners must finish increasingly larger parts of the solution, and conventional tasks	For students learning to set up treatment plans, first let them study and criticise ready-made treatment plans, then let them finish partially completed treatment plans, and finally let them independently develop whole treatment plans
Fading guidance strategy	Replace a uniform series of conventional tasks with a varying series of tasks that provide sizable learner guidance in the beginning but gradually decrease guidance until no guidance is given (i.e. 'scaffolding')	When students are learning to catheterise, first provide them with step-by-step instructions and feedback, then only provide them with feedback, and finally provide no guidance at all
Integrated to non-integrated strategy	Replace a uniform series of integrated examples with a two-stage series of integrated examples followed by non-integrated examples, which present only the picture or only the text	Illustrate a new surgical procedure to medical students by presenting integrated pictures and text, but only use the pictures for experienced surgeons
Dual- to single-mode strategy	Replace a uniform series of dual-mode presentations with a two-stage series of dual-mode presentations followed by single-mode presentations, which eliminate the auditory information	Give students spoken explanations when they study a computer animation of the working of the digestive tract, but switch off the sound for more experienced students

From “Cognitive load theory in health professional education: Design principles and strategies,” by J. J. G. van Merriënboer and J. Sweller, 2010, *Medical Education*, 44, p. 88. <https://doi.org/10.1111/j.1365-2923.2009.03498.x>. Blackwell Publishing Ltd. Reprinted with permission.

Kirschner (2002) explains that intrinsic cognitive load, which reflects the “intrinsic characteristics of the task or subject matter” (p. 4) is not particularly influenced by altering instructional interventions. However, extraneous and germane cognitive load may be influenced (extraneous reduced, and germane optimized) by instructional design. As a reminder, extraneous cognitive load is extra effort put forth to deal with poorly designed instruction, while germane cognitive load (desirable) is the effort that results in schema formation (Kirschner, 2002). Jordan et al. (2019) offered suggestions for optimizing instructional design to reduce extraneous load (minimizing environmental distractions, optimizing room set-up and audiovisual support, focus on learning objectives, use job aids with graphics (not just text), and rehears in advance).

Suggestions to optimize germane load include using schema to present information, chunking information in a meaningful way, using concept mapping, and gradually withdrawing support as learners gain greater skills (Jordan et al., 2019).

Despite Kirschner's (2002) assertion that intrinsic load *is what it is*, and cannot be influenced by varying instructional techniques, Jordan et al. (2019) argued that this is not entirely correct. The instructor can more carefully consider the appropriateness *of* the intrinsic load and employ techniques such as reminding students of prior learning, limiting the amount of content to be covered, assuring content flows from simple to complex, and has the best alignment with learner skills level and experience (Jordan et al., 2019). Kirschner elaborates (2002) stating "instructional interventions cannot change the intrinsic cognitive load because this is *ceteris paribus* [with other conditions remaining the same] intrinsic to the material being dealt with" (p. 4). Jordan and others argued that perhaps by changing the *other conditions* we can lower intrinsic cognitive load (Jordan et al., 2019).

Sewell et al. (2019) conducted a scoping review of studies involving cognitive load and mental effort or workload in the professional workplace, with the goal of informing teaching, learning, and research in health professions workplaces. Much of this literature can be challenging to interpret; Sewell et al. (2019) stated that most of the studies reviewed *inferred* overall cognitive load as being intrinsic load (e.g., "inherent difficulty of the required components of a learning task," p. 263). The authors also stated that *how* investigators measured or evaluated cognitive load is disparate and challenging. Studies employed psychometric, physiologic, and secondary task approaches to measure cognitive load and approaches were too unrelated to allow drawing conclusions.

While the authors identified several gaps in the existing literature, they did provide several recommendations for workplace teaching and curricular design. First, they suggested learners be presented with learning tasks of *appropriate* complexity that match the level of the learner; again, this is reinforcing the point that Kirschner (2002) makes that the intrinsic cognitive load is inherent to the material being dealt with, educators may choose to select more appropriately suited learning tasks (thereby optimizing germane load).

Sewell et al. (2019) also speculated on how various work factors contributed to cognitive load, how the cognitive load level impacts learning, what role emotions and mindset play, how differing levels of prior knowledge impact cognitive load, what role the interprofessional nature of the workplace play in this experience, and how learners identify and deal with their own cognitive overload, stress, and burnout. The authors categorized best practices to optimize cognitive load in health professional's workplace in four areas: curricular design, direct teaching, learning environment, and metacognition (Table 2.1).

**Table 2.1**

*Practical Suggestions for ‘Best Practices’ to Optimize Cognitive Load in Health Professionals*

*Workplaces*

Best practices	Evidence	Practical suggestions
<b>Curricular Design</b>		
Ensure overall cognitive load (CL) or intrinsic load of individual learning settings are not <i>too high</i>	Performance negatively associated with intrinsic load and overall CL in numerous studies, implying reduced learning when these are too high If intrinsic or overall CL is too high, space for activities contributing to germane load will be limited.	<ul style="list-style-type: none"> <li>• Minimize task complexity for early learners (e.g., partial task, worked examples) (Chen et al., 2015)</li> <li>• Minimize task complexity when introducing new technologies or methods by providing time, develop a stepwise process</li> <li>• Monitor learners’ competence to know when to increase complexity</li> <li>• Scaffold and sequence curriculum to gradually increase complexity over time</li> <li>• Use 4C/ID approach to design individual teaching sessions (Vandewaetere et al., 2015)</li> <li>• Systematically assign patients based on competence (Young et al., 2010)</li> </ul>
Ensure overall CL or intrinsic load of individual learning settings are not <i>too low</i>	Higher complexity tasks associated with higher intrinsic <i>and</i> higher germane load among more advanced learners (Dankbaar et al., 2016). No studies specifically investigated cases in which intrinsic load might be too low, but this could plausibly occur, inducing expertise reversal effect (Kalyuga et al., 2003).	<ul style="list-style-type: none"> <li>• As above</li> </ul>

Table 2.1 continued on next page

Use simulation for early learners, especially when actual tasks involve potential for patient risk and/or have significant element interactivity	Simulation enables control over complexity and deliberate practice (Ericsson, 2004), which should enhance learning. Lower complexity simulation associated with lower CL and better performance (proxy for learning) among novice learners (Chen et al., 2015b; Haji et al., 2015; Tremblay et al., 2017). Studies did not compare simulation with actual patient care.	<ul style="list-style-type: none"> <li>• For procedural skills, build basic skills with simulator, then when competence demonstrated, begin to work with real patients (see: Learn, See, Practice, Prove, Do, Maintain approach (Sawyer et al., 2015))</li> <li>• For cognitive skills, start with simple paper-based cases and then increase complexity of simulation before working with real patients</li> <li>• Monitor lag between training and actual use of skills; may need to plan for practice to bring skills back up to prior level of training</li> </ul>
Appraise all aspects of workplaces and associated tasks to identify areas with high potential for cognitive overload	Specific portions of workplace tasks were associated with different levels of CL (Dahlstrom & Nahlinder, 2009; Gaba & Lee, 1990; Moos & Pitton, 2014; Murai et al., 2010; Shachak et al., 2009; Walker & von Bergmann, 2015; Weinger et al., 2000).	<ul style="list-style-type: none"> <li>• Use cognitive task analysis to identify complex areas (Walker &amp; von Bergmann, 2015; Young et al., 2016)</li> <li>• Orient learners to whole task but allow part task practice until able to accomplish entire task, i.e., 4C/ID (Vandewaetere et al., 2015)</li> </ul>
Standardize common tasks, providing supports when needed	Checklists and diagnostic aids reduced CL and improved performance (Liang et al., 2010; Sibbald et al., 2013a; Sibbald, et al., 2013b).	<ul style="list-style-type: none"> <li>• Use checklists or standard protocols for common, complex, high-risk activities such as patient hand-offs</li> </ul>
Design curricula to support workplace learning that scaffold tasks, gradually increasing complexity and reducing support	No curricular studies were identified, but indirectly supported by studies noted earlier in this table, and commentaries suggest benefit (Leppink & Duvivier, 2016).	<ul style="list-style-type: none"> <li>• Consider how workplace rotation schedule and didactic teaching can be used to scaffold learning for critical tasks (Chen et al., 2015)</li> </ul>
Facilitate mixed or random practice over block practice	Lower CL and better performance with mixed or random practice compared with block practice (Chen et al., 2015a; Shewokis et al., 2017).	<ul style="list-style-type: none"> <li>• Integrate skills sessions throughout a curriculum that involve a mixed or random set of cases or diagnoses</li> </ul>

Table 2.1 continued on next page

<b>Direct Teaching</b>		
Teacher should remain engaged with learning, limiting tangential conversations	Greater teacher engagement associated with higher germane load and lower extraneous load (Sewell et al., 2017) Tangential conversations associated with higher CL, lower performance (Gardner et al., 2016).	<ul style="list-style-type: none"> <li>• Regularly evaluate teachers' performance and provide constructive feedback</li> <li>• Provide faculty development for teaching engagement techniques, including minimizing tangential conversations which may not over-tax experts but can overload less experienced trainees</li> <li>• Minimize competing duties and distractions for clinical faculty when they are working with learners in the workplace</li> </ul>
Teach teachers to monitor for cognitive overload in learners	Although no studies addressed this, teachers are in unique position to observe learners' behavior for cues suggestive of cognitive overload.	<ul style="list-style-type: none"> <li>• Observe learners' body language and utterances for hints of cognitive overload and adjust teaching and level of support accordingly</li> </ul>
Attend to learner emotion, especially in crisis situations	Negative emotions negatively affected learning (Fraser et al., 2012; Fraser et al., 2014). Crisis situations were associated with higher levels of CL and lower performance (Boet et al., 2017; Davis et al., 2009; Fraser et al., 2014; Wucherer et al., 2015); debriefing may help (Boet et al., 2017).	<ul style="list-style-type: none"> <li>• Debrief after crisis situations</li> <li>• Provide faculty development to help faculty recognize learner emotions and to manage crisis situations and debriefing</li> <li>• When learners display external evidence of negative emotions, discuss with them and facilitate reflection, providing supportive services when needed</li> </ul>
<b>Learning Environment</b>		
Leverage graphical displays and technology to reduce extraneous load	Graphical representations of complex data were associated with lower CL and better performance (Doig, et al., 2011; Dominessy et al., 1991; Workman et al., 2007) . Well-designed electronic interfaces (e.g., order sets) were associated with lower CL and better performance (Avansino & Leu, 2012; Saleem et al., 2007). Consistent with Cognitive Theory of Multimedia Learning (Mayer, 2009).	<ul style="list-style-type: none"> <li>• Critically evaluate tools learners use in clinical settings, optimizing or changing products and interfaces when needed</li> <li>• Thoroughly orient learners to best uses of technology in the workplace – mixed approaches may be most beneficial (Maxwell &amp; Zheng, 2017)</li> <li>• Seek learner input for modifiable electronic health record-related tools such as note templates, order sets, and boilerplate phrases</li> </ul>

Table 2.1 continued on next page

Monitor learning environments for complexity, distractions, and contextual factors that may induce cognitive overload	More complex simulated environments increased extraneous load and decreased performance in novices (Tremblay et al., 2017). Contextual factors increased cognitive load and reduced performance, even in experienced physicians (Durning et al., 2012).	<ul style="list-style-type: none"> <li>• Critically evaluate workspace and workflow, considering aspects that can be improved to reduce distractions and other sources of extraneous load</li> </ul>
Engineer workplace environments to minimize distractions and redundancy	Re-engineered workplace reduced disruptions, lowered CL, and increased satisfaction (Lee et al., 2017).	<ul style="list-style-type: none"> <li>• Ask learners what challenges they face in the physical work environment</li> <li>• Involve learners in environment change, possibly as quality improvement effort</li> </ul>
Monitor for, and mitigate, learner fatigue	Fatigue was positively associated with extraneous load and overall CL (Bertram et al., 1990, 1992; Sewell et al., 2017).	<ul style="list-style-type: none"> <li>• Proactively identify learning settings in which fatigue is common</li> <li>• Adjust tasks, schedules and support to mitigate effects of fatigue on CL</li> </ul>
<b>Metacognition</b>		
Help learners know where to direct their limited working memory resources	Specific portions of workplace tasks were associated with different levels of CL (Dahlstrom & Nahlinder 2009; Gaba & Lee 1990; Moos & Pitton, 2014; Murai et al., 2010; Shachak et al., 2009; Weinger et al., 2000; Walker & von Bergmann 2015).	<ul style="list-style-type: none"> <li>• Deconstruct whole tasks into partial tasks, i.e., 4C/ID (Vandewaetere et al., 2015), and prepare learners for those that are likely to be most cognitively demanding</li> </ul>
Teach learners to manage distractions	Distractions were present in workplace settings (Haji et al., 2016; Thomas et al., 2017; Weigl et al., 2015).	<ul style="list-style-type: none"> <li>• Teach learners that distractions are commonly present in HPE workplaces</li> <li>• Deconstruct with learner's typical distractions in the workplace</li> <li>• Simulate distractions and teach skills that help learners manage distractions</li> </ul>
Teach learners to monitor their level of CL and communicate feelings of cognitive overload	Learners may be able to recognize when they are cognitively overloaded (Moos & Pitton, 2014).	<ul style="list-style-type: none"> <li>• Teach learners about CL and provide them language to communicate feelings of overload</li> <li>• Simulate or role-play learners telling their supervisor they feel cognitively overloaded</li> <li>• Provide faculty development so that teachers can respond to learners' cognitive overload</li> </ul>

Table 2.1 continued on next page

Teach learners to use metacognitive techniques to enhance learning	Metacognition was not explicitly studied, but benefits are inferred by tenets of CLT.	<ul style="list-style-type: none"> <li>• Teach learners how to use metacognitive techniques such as self-explanation and monitoring and confirming understanding.</li> </ul>
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From “Cognitive load theory for training health professionals in the workplace: A BEME review of studies among diverse professions: BEME Guide No. 53,” by J. L. Sewell, L. A. Maggio, O. ten Cate, T. van Gog, J. Q. Young and P. S. O’Sullivan, 2019, *Medical teacher*, 41(3), Supplement pp. 1-4 (<https://doi.org/10.1080/0142159X.2018.1505034>). Copyright 2019 by Informa Healthcare in collaboration with the Association for Medical Education in Europe. Reprinted with permission.

Sewell et al., (2019) has provided practical information for curricular design, direct teaching, how to modify the learning environment, and how to foster metacognition among learners. The next section will address superimposing theories promulgated by the CTML to further optimize cognitive load.

### ***Mayer’s Cognitive Theory of Multimedia Learning***

Mayer (2021), built on the work of others (Baddeley, 1992; Sweller, 2010), and the active processing assumption in the development of the CTML, in making three assumptions:

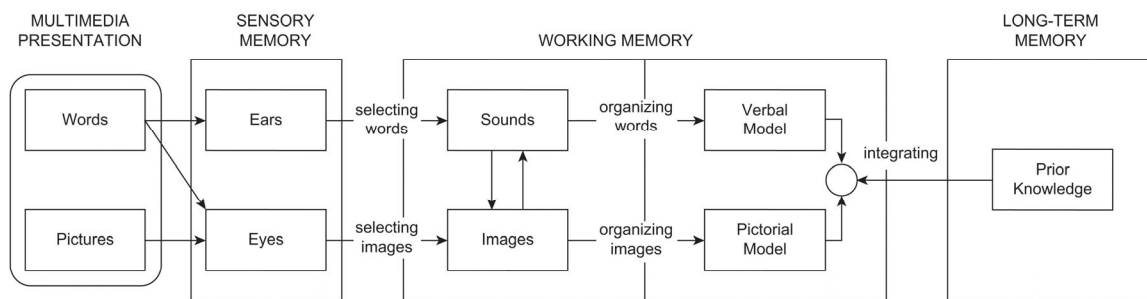
- Humans possess separate channels for processing visual and auditory information.
- Humans are limited in the amount of information that can be processed in each channel at one time.
- Humans engage in active learning by attending to relevant incoming information, organizing selected information into coherent mental representations, and integrating mental representations with other knowledge.

Mayer’s assertions that humans have different and separate channels for processing visual/spatial material and auditory/verbal material is a large part of the CTML. We can understand the differences between the two channels based on representation mode (e.g., stimulus can be verbal [spoken or printed words] or nonverbal [pictures, photos, video, animation, etc.]), where one channel processes verbal material and the other channel processes nonverbal sounds and pictorials (Mayer, 2021).

Further, we can consider the sensory-modality approach where learners process new material through their eyes (pictures, photos, video, etc.) or ears (spoken words or background sounds). Mayer (2021) contends that learners may be able to convert the representation for processing new information presented to one channel to the alternate channel. For example, an image (presented to one channel) may be mentally converted to a sound (interpreted in the alternate channel). Or a narration (presented to one channel) may be used to form a mental image in the alternate channel (see Figure 2.5).

**Figure 2.5**

*Cognitive Theory of Multimedia Learning*



From *Multimedia Learning*, 3<sup>rd</sup> ed. (p. 40) by R. E. Mayer, 2021, Cambridge University Press (doi:10.1017/9781316941355). Copyright 2021 by Richard E. Mayer. Reprinted with permission.

The limited capacity assumption is consistent with Sweller’s (2010) assertion that working memory is a capacity-limited process. The work popularized by Miller (1956) demonstrated that the average memory span is about five to seven chunks of information. The third assumption, active processing, states that learners need to actively engage in the process of receiving and processing new information. Mayer (2021, p. 39) explains that there are three

cognitive processes required for active learning: selecting (“attend to relevant material in the multimedia lesson and transfer it to working memory”), organizing (“mentally arrange selected information into a coherent cognitive structure in working memory”), and integrating (“connect cognitive structures with each other and with relevant prior knowledge activated from long-term memory”).

Mayer (2021) concurs with Sweller’s (2010) explanation of demands on cognitive capacity (intrinsic, extraneous, and germane cognitive loads), referring to the three demands on cognitive capacity as extraneous, essential (Sweller’s intrinsic cognitive load) and generative processing (Sweller’s germane cognitive load) (see Table 2.2).

**Table 2.2**

*Comparison of Sweller and Mayer Theories on Cognitive Capacity Demands*

Sweller’s Term	Mayer’s Term	Mayer’s Principles
Intrinsic cognitive load	Essential processing	<ul style="list-style-type: none"> <li>• Segmenting principle</li> <li>• Pre-training principle</li> <li>• Modality principle</li> </ul>
Extraneous cognitive load	Extraneous processing	<ul style="list-style-type: none"> <li>• Coherence principle</li> <li>• Signaling principle</li> <li>• Redundancy principle</li> <li>• Spatial contiguity principle</li> <li>• Temporal contiguity principle</li> </ul>
Germane cognitive load	Generative processing	<ul style="list-style-type: none"> <li>• Multimedia principle</li> <li>• Personalization principle</li> <li>• Voice principle</li> <li>• Image principle</li> <li>• Embodiment principle</li> <li>• Immersion principle</li> <li>• Generative activity principle</li> </ul>

Mayer (2021) conducted extensive research in a variety of retention and transfer testing experiments that aimed to manage essential processing, optimize and reduce extraneous

processing, and promote generative processing. He developed fifteen principles within these three cognitive process categories, including principles for reducing extraneous processing (5 principles), principles for managing essential processing (3 principles) and principles for fostering generative processing (7 principles). Table 2.3 describes each principle and summarizes the data supporting or refuting each principle, and how the relevant principles were used to adapt the initial design of both medication infographics used in the present research study.

**Table 2.3**

*Principles for Multimedia Instruction*

<b>Principle</b>	<b>Description</b>	<b>Evidence</b>	<b>Example of Implementation in Proposed Research</b>
<b>Principles for Reducing Extraneous Processing</b>			
Coherence Principle	Eliminating interesting but irrelevant words and pictures, unneeded words and symbols, and irrelevant music from the multimedia presentation enhances learning	In 18 of 19 transfer tests, learners performed better when extraneous material was removed. This resulted in a large median effect size (0.86).	Pictures that did not add to the educational message were removed. Some images were reduced in size to allow room for more pertinent images. In several instances more relevant images were selected.
Signaling Principle	Adding highlighted cues that assist in organizing essential material enhances learning	In 15 of 16 transfer tests, the addition of verbal signaling resulted in better learning with a median effect size of 0.69	A red “stop sign” was added to draw attention to the segment on “serious side effects – call your nurse.” This section was also at the bottom of the page and was initially allocated a disproportionately smaller amount of space, which was corrected.

Table 2.3 continued on next page

Redundancy Principle	Adding printed text to narration and graphics does not enhance learning, especially with a fast-paced lesson.	In 8 of 12 transfer tests with graphics and narration out-performed lessons that also included graphics with a very small effect size (0.1). When the lesson was fast paced, the elimination of printed text resulted in a median effect size of 0.72.	NA
Spatial Contiguity Principle	Learning is enhanced when corresponding words and pictures are physically located near each other, rather than at a distance.	In 9 of 9 transfer tests, learners performed better when words and corresponding pictures were placed near each other, rather than far away. The effect size was large with a median effect size of 0.82.	Images were placed directly next to pertinent words. For example, an icon showing putting a tablet in the mouth was placed directly next to the words "Take it by mouth."
Temporal Contiguity Principle	Learning is better when words and corresponding pictures are presented at the same time, as opposed to sequentially.	In 8 of 8 transfer tests, learners performed better with simultaneous picture/word presentation, showing a large median effect size of 1.31.	NA
<b>Principles for Managing Essential Processing</b>			
Segmenting Principle	User-paced segments result in better learning than material presented as a continuous unit.	In 7 of 7 transfer tests, presenting the lesson in bite-sized segments as opposed to a continuous unit resulted in better learning. This showed a moderately large median effect size of 0.67.	Headers were added for each "chunk" of information including "How will this medicine help me?" "How and when do I take the medicine" and "When will it work," "Common side effects," and "Serious side effects? Call your nurse"

Table 2.3 continued on next page

Pre-training Principle	Learners perform better when they know the names and characteristics of main concepts.	In 10 of 10 transfer tests, pre-training on the names and characteristics of key lesson components resulted in superior outcomes. This practice resulted in a median effect size of 0.78.	Because the two medications used the proposed research have fairly similar names (hydromorphone and hydroxyzine), a pre-training leaflet infographic was prepared, showing each generic drug name with TALL man letters, which point out the difference and pronunciation emphasis (e.g., hydroMORphone and hyDROXYzine). Also, trade names were added (hydromorphone – Dilaudid; hydroxyzine – Vistaril or Atarax)
Modality Principle	Learners perform better from pictures and spoken words as compared to pictures and printed words.	In 18 or 19 transfer tests, learners exposed to graphics plus narration outperformed those receiving graphics and onscreen test. The median effect size was 1.00.	NA
<b>Principles for Fostering Generative Processing</b>			
Multimedia Principle	Learners perform better from words and pictures than from words alone.	In 13 of 13 transfer tests, lessons that included text and illustrations or narration plus animation performed better than those exposed to text or narration alone. The median effect size was quite large, at 1.35.	NA
Personalization Principle	Narration in a conversational style as opposed to a formal style result in better learning.	In 13 of 15 transfer tests subsequent to a lesson narrated in a conversational style vs. a formal style performed better, resulting in a large median effect of 1.00.	Anywhere the infographic referred to calling “the” nurse was changed to call “your” nurse to enhance personalization.
Voice Principle	Narration in an appealing human voice results in better learning as opposed to a machine-synthesized voice.	In 6 of 7 transfer tests, an appealing human voice narration resulted in better performance, with a median effect size of 0.74.	NA

Table 2.3 continued on next page

Image Principle	Learning is NOT enhanced when a static image of the instructor is added to the screen.	In 4 of 7 transfer tests where a static image of the instructor was added to the lesson, subjects performed more poorly or only slightly better than those experiencing a lesson without the static image. The median effect size was 0.20 favoring the static image (considered a small or negligible effect).	NA
Embodiment Principle	When the onscreen instructor displays high embodiment (e.g., human-like gestures, body movements, facial expression, etc.) as opposed to low embodiment, learning is enhanced.	In 16 of 17 transfer tests, a high-embodied instructor performed better than low-embodied with a median effect size of 0.58.	NA
Immersion Principle	3D immersive virtual reality does not necessarily result in better learning than a 2D desktop presentation of the same content.	In 6 of 9 transfer tests, learners who received the 3D immersive reality performed more poorly than those exposed to the 2D desktop version. The median effect size was -0.10, favoring the 2D presentation over the 3D.	NA
Generative Activity Principle	Learners perform better when guided in executing generative learning activities (activities that foster learning such as drawing, self-testing, etc.)	In 37 of 44 transfer tests, learners who were prompted to engage in generative learning activities performed better than learners not engaged in these activities. The median effect size was 0.71.	After viewing each infographic (hydromorphone and hydroxyzine), learners completed an assessment activity (quiz)

From *Multimedia Learning*, 3<sup>rd</sup> ed. (pp. 397-415) by R. E. Mayer, 2021, Cambridge University Press (doi:10.1017/9781316941355). Copyright 2021 by Richard E. Mayer.

Seven of the 15 principles endorsed by Mayer (2021) are applicable to this study.

**Coherence Principle.** The coherence principle states that learners understand a multimedia lesson better when it is more concise with extraneous words and pictures eliminated

(Mayer, 2021). There are three variations of this principle: 1) Eliminating interesting but unnecessary words or pictures; 2) Removing non-essential words and pictures improves learning; and 3) Removing unnecessary background music improves learning (Mayer, 2021). The first two variations are relevant to this research study.

Educators are often tempted to add interesting words or pictures to a multimedia presentation thinking it will make for better learner engagement and attraction. But does this enhance or detract from student learning? Harp and Mayer (1997, 1998) conducted five experiments with a paper-based multimedia model. The lesson was on lightning formation, comparing exposure to a concise booklet with 5 paragraphs and 5 illustrations, to an expanded booklet on lightning that had the same content plus additional illustrations and captions of interesting and related facts. Learners performed better on a knowledge transfer test after viewing the more concise booklet, showing a large effect (1.27-1.68).

The second variation on the coherence principle examines if students learn better from a multimedia summary versus a full lesson. Continuing with the lightning theme, Mayer et al. (1996) compared knowledge transfer in learners who reviewed a multimedia summary lesson on lightning, to learners who received a full lesson, which contained an additional 550 words of text. Two of their three experiments showed improved assessment scores of learners who viewed the multimedia summary, showing a large effect (0.7, 0.98).

In this study, when reconsidering the design of the infographics, several pictures were removed. These images had originally been included to stimulate interest in the infographic, but they did not specifically support the educational message. Also, several images were reduced in size to allow better alignment with the educational message (e.g., the words).

**Signaling Principle.** The signaling principle incorporates cues to direct the learner's attention to essential material. This could include the use of outlining, headlines, pointer words, graphic organizers, using color or bolding fonts, or using vocal emphasis for narrated multimedia presentations (Mayer, 2021). There are two variations of the signaling principle – verbal signaling and visual signaling. The latter is relevant to the proposed research. Twelve research projects have investigated the impact of using visual signaling (cueing) such as highlighting key components with distinctive coloring. These projects primarily involved computer screen multimedia instruction, using techniques such as color coding (where the color of key components change color when being discussed or emphasized by the narrator) (Mautone & Mayer, 2001; Wang et al., 2018; Xie et al., 2019). This series of studies showed mixed results (effect size -0.03 to 0.86; median effect size 0.69).

Another series of experiments (also computer screen-based and narrated) used the technique of specific pointing gestures. Three experiments compared a narrated presentation where an animated character used a pointer stick to refer to the image being discussed. When compared to narrated presentation that did not use specific pointing gestures, students performed significantly better on knowledge transfer tests (Li et al., 2019; Wang et al., 2018). In this study, a red stop sign was added to the segmented chunk on serious medication side effects to draw attention to the seriousness of the situation.

**Spatial Contiguity Principle.** The spatial contiguity principle states that people learn better when corresponding words and pictures are positioned near each other, as opposed to far apart from each other (Mayer, 2021). Mayer and colleagues conducted a series of experiments evaluating knowledge transfer after exposure to learning objects (printed page or computer

screen) where text and graphics were placed near each other, versus far apart (Johnson & Mayer, 2012; Makransky et al., 2019; Mayer, 1989; Mayer et al., 1995; Moreno & Mayer, 1999). For example, (Mayer, 1989), students viewed a page explaining how the brakes work on a car. In one group, the illustrations were placed next to the explanatory text. In the other group, the explanations were on one page, and the illustrations on the next page. The learners in the group with images and words together strongly outperformed the comparison group. In this research study several images on the drafted infographics were realigned to place them directly next to the applicable words. Icons and images were also more carefully considered to reflect the words to which they were adjacent.

**Segmenting Principle.** The segmenting principle states that learners perform better when multimedia education is presented in user-paced segments, as opposed to a continuous flow of information (Mayer, 2021). Most of the research done on this principle has evaluated breaking continuous animation into shorter segments with presentation under the learner's control. Mayer and Chandler (2001) evaluated one group of learners watching a 140 second continuous presentation on lightning, and a second group watching the same presentation broken into 16 segments. The learner had to click the "continue" button in the second group. On a transfer test of knowledge, the learners exposed to segmenting performed statistically significantly better with a large effect (1.13). Sung and Mayer (2013) conducted a similar experiment where students viewed a continuous 6-minute narrated multimedia lesson, and another group of students viewed the same lesson broken into 11 segments, and the student had to click a button to go on to the next segment. There was a statistically significant difference in knowledge transfer with a medium effect size seen between the two groups.

The multimedia used in this research is not a narrated presentation, but the initially drafted infographics were amended to show clear sections of content, instead of one continuous document. This also included adding headers for each chunk of information such as “How will this medicine help me?” “How and when do I take the medicine?” and “When will it work?” “Common side effects?” and “Serious side effects? Call your nurse.”

**Pre-training Principle.** The pre-training principle states that people learn better from multimedia learning when they are provided with knowledge that will help the learner process the learning, before the actual education (Mayer, 2021). This may include defining new terms or abbreviations, describing components of a system, naming and identifying items, and so forth. Mayer et al. (2002) conducted a series of experiments evaluating the impact of pre-training students prior to watching a narrated animation on the braking system of a car. For the intervention group they provided a learning activity stating the name and possible states of each component of the braking system via interactive computer tutorial. The tutorial was a point and click with the click providing an explanation of the role of the component and how it worked. On a knowledge transfer assessment, students who received pre-training achieved a statistically significantly higher score, with a medium to large effect size (.057-1.0).

In another study, Gegner et al. (2009) had students read an article on the effects of drug and alcohol abuse. Half the cohort received pre-training that included text and video clips before reading the article, while the other half of the cohort did not. Those who received the pre-training scored statistically significantly better on a comprehension test than those who did not, with medium to large effect sizes (0.69, 0.96).

Because this proposed study involves IFCs viewing medication information leaflets on two medications that have similar-looking names, pre-training was developed. An infographic was prepared, distinguishing between the two study medications (hydromorphone and hydroxyzine). The trade names were added (Dilaudid for hydromorphone; Vistaril or Atarax for hydroxyzine), and the generic names were written out using tall man lettering (ISMP, 2019), which is a technique used to indicate pronunciation emphasis (e.g., hydroMORphone and hyDROXYzine), for look-alike, sound-alike medications.

**Personalization.** The personalization principle states that individuals learn better when the words are used in a conversational style instead of a more formal manner (Mayer, 2021). In a series of studies Moreno and Mayer (2000) had students view a 140-second narrated animation about lightning. For the intervention group, the speaker used a conversational tone, using words such as “I” and “you.” In the control group, the speaker used a more formal tone, did not use “I” or “you” or speak directly to the learner. Otherwise, the presentations were identical. On a knowledge transfer test, the personalized presentation recipients showed statistically significantly better performance than the control group, with large effect (1.05, 1.61).

Interestingly, Mayer et al. (2004) evaluated the single intervention of changing the work “the” to “you” in a 60-second narrated animation about the human pulmonary system. This simple substitution resulted in medium to large effects sizes favoring personalization (0.52-1.0). Similarly, in this study, any reference to “the” nurse on the drafted infographic sheets was changed to “your” nurse.

**Generative Activity Principle.** The generative activity principle states that individuals learn better when they apply newly learned information (Mayer, 2021). Eight potential types of

generative activities include summarizing, mapping, drawing, imaging, self-testing, self-explaining, teaching, or enacting (Mayer, 2021). There is extensive research on each of these eight types of generative activities. The self-testing principle is most closely aligned with this proposed study. Studies by Mayer and colleagues (Mayer, 1975, 1980; Sagerman & Mayer, 1987) confirmed this effect by asking learners to respond to conceptual questions after each section of an instructional booklet. Those who responded to these questions performed better on a knowledge transfer test than students who did not have those questions inserted.

As noted in the presentation of the principles, the majority of the work conducted by Mayer and colleagues on the CTML was performed with college students in an effort to understand learning in an education setting. The majority of students at a 4-year institution are under the age of 25, therefore, the findings may not apply in different populations, such as IFCs, who are typically older (National Center for Education Statistics, 2022).

### **Infographics and Learning**

According to the CTML, people learn better from words and pictures as opposed to words alone. Therefore, infographics (which combine words and pictures) may prove to be a useful tool in education. An “infographic” is an abbreviated description of an “information graphic” (Scott et al., 2016a, p. 1104). Using graphic depictions as a representation of information is not a new concept, as evidenced by pre-historic cave drawings. The adage “a picture is worth a thousand words,” which has been credited to a variety of individuals (Henrik Ibsen, Tess Flanders, Fred R. Barnard) (Wikipedia, 2021), represents the concept underlying an infographic. An infographic has been described as a new way to visualize data, also termed, “information visualization.”

The aim of information visualization is to communicate information more clearly and effectively by using graphical means (Siricharoen, 2013). The three main components of an infographic are 1) “visual (colors and graphics), 2) content (data, statistics and/or facts) and 3) knowledge (analysis or insight into the data)” ( PHS Digital Library, 2022). Infographics are used for an ever-increasing number of purposes including marketing, news, presenting data, showing cause and effect, study aids, creating maps, networking, resumes, displaying scientific data on a poster, and numerous educational applications. Scott et al. (2016b) suggest that every research paper should be accompanied by an infographic to enhance understanding and retention.

### **Designing Infographics**

To be useful educational tools, infographics must be more than eye-catching. Infographics should be designed from a neuroscience perspective, through the integration of established research on how people learn, reducing cognitive load by adjusting intrinsic load, reducing extraneous load, and maximizing germane load (Hays, 2016). The suggested elements outlined in the Common Core State Standards (Davis & Quinn, 2014) for writing in the development of an infographic include:

- Purpose – should be clear, reader should be able to draw conclusions on the evidence, and summarize the message
- Style – layout, text, symbols and color schemes should convey a consistent theme
- Evidence – data and text must be referenced and integrated into the design
- Format – may be static or dynamic

Key principles for designing a medical infographic including considerations for the target audience are a compelling title (which has been shown to be the number one variable to draw a

reader's attention), emphasis on the key messages, use of arrow and lines to guide narrative, a balance between elements (visualizations, images, words with sparing use of text) and limit colors and fonts (Wansink et al., 2016). Importantly the readability level should target between fourth and sixth grade (Royal & Erdmann, 2018), although this may be less appropriate for advanced learners such as health profession students and health care providers. Lastly, Hernandez-Sanchez et al. (2020) offers twelve tips to make successful infographics specific to healthcare professionals, patients, and undergraduate health science students (Table 2.4).

**Table 2.4**

*Twelve tips to make successful medical infographics*

- 
1. Define the target audience: know their preferences, and gain impact
  2. Set the purpose of the infographic
  3. Think of a compelling title to attract and sustain the audience's attention
  4. "Get straight to the point": be transparent
  5. Storytelling is key
  6. Find a way to highlight the main idea
  7. Draft the infographic
  8. Follow the basic principles of graphic design
  9. Choose colors appropriately
  10. Test the infographics and try to enrich it
  11. Properly review the infographics to avoid misprints and errors
  12. Disseminate and share the infographics efficiently
- 

From: "Twelve tips to make successful medical infographics," by S. Hernandez-Sanchez et al., *Medical Teacher*, 43(12), pp. 1353-1359. Copyright by Informa Healthcare in collaboration with the Association for Medical Education in Europe. Reprinted with permission.

## **Infographics in Health Education**

In theory, infographics seem to be an ideal tool to maximize the CTML. The remainder of this section will evaluate published literature on the use of infographics in health education, measuring learner perceptions and knowledge gain. Some literature involves a student-generated infographic, while other literature evaluates outcomes from an instructor-developed infographic. While the target population in the research conducted is lay persons (IFCs), the evidence base is

not robust, therefore data in additional populations (undergraduate and graduate health profession students, and practicing healthcare providers) will also be discussed, particularly where the CTML is discussed or incorporated in infographic design.

### ***Lay Persons (Patients, Caregivers, Consumers)***

Determining whether infographics have a positive impact on patients, caregivers, or consumers' beliefs, perceptions, or knowledge about health-related issues could have implications for healthcare professionals (trainees and practitioners). If educational benefit is shown using infographics in instructional or training interventions, this could potentially play an important role in the education healthcare providers provide to their patients and their families.

For example, a study by Damman et al. (2018), examined patients' understanding of cardiovascular disease risk in two conditions, text vs. infographics. While there was improvement in some areas, overall, the infographic group performed poorer than the text group in recall and comprehension. The infographic group performed particularly poorly as compared to text in those with lower numeracy and health literacy. The authors concluded that it was worth investigating whether dynamic infographics may provide greater explanation, resulting in better outcomes. The study was interesting in that a portion of the methods are similar to this research study (text vs. infographics) but disappointing that the infographic group had poorer knowledge recall and comprehension. Given that this was closely associated with those having lower numeracy and literacy, it was important to include study subjects of all literacy levels in this study.

Buljan et al. (2018) assessed changes in knowledge in three different populations using an infographic vs. more traditional methods. Three methods were compared to summarize a

systematic Cochrane review on external cephalic version for breech presentation at term as either an infographic, plain language summary (PLS) or scientific abstract (SA). Three groups were included in the comparison: consumers (female members of the Association for the Promotion of patients' Rights, and of the RODA Parents in Action consumer group for pregnancy and parenting [RODA is the Croatian word for stork]), students (first year medical students, and students in a humanities course in the School of Humanities and Social Sciences) and physicians (in any specialty). The consumers received either the infographic or the PLS; students and physicians were randomized to either the infographic, the PLS or the SA (SA is not intended for a consumer audience). A ten-question assessment of content was administered to all groups. Reading experience and user-friendliness of the format was assessed in all groups using a 5-question survey (level of agreement). There was no difference in knowledge between the methods, although infographics received higher ratings for the reading experience. The methods in the study by Buljan et al. (2018) inform the design of this research knowledge acquisition from infographic vs. text; however, their study does not state if the infographics were developed according to a learning theory, like CTML. While (Buljan et al., 2018) study confirmed that infographics tend to be more visually appealing than words alone, this current study assessed knowledge retention when infographics were designed using the principles of CTML.

Becker et al. (2020) evaluated the utility of an infographic vs. text to prompt parents to learn more about substance use disorder in adolescents. Parents of adolescents who had a substance use disorder history or were experiencing legal consequences from substance misuse were more likely to request additional information. In addition, parents who reviewed the infographic, written at a 7<sup>th</sup>-grade level, were more likely to request additional information than

those who viewed the text description, which was written at the 12<sup>th</sup>-grade level. It seems reasonable that a more dire situation would prompt parents to request more information. Also, the disparity in reading level may have been the reason parents who read the infographic were more likely to request additional information, vs. those who read the text leaflet. Further, the results from the comparison of an infographic vs. text could reflect the reading level (7<sup>th</sup> grade vs. 12<sup>th</sup> grade) and not the method of delivery (infographic vs. text). In this study, both the infographic and text medication information leaflet were prepared at a 4.6 grade reading level.

Dowling et al. (2019) investigated the impact of a patient-focused infographic explaining the appropriate role of imaging secondary to minor traumatic brain injuries (TBI). Compared to a baseline survey, family members demonstrated improved understanding of when imaging (CT scan) was appropriate following minor TBI, after reviewing the infographic. This study would have been strengthened by comparing family member understanding after reading a text passage about the appropriate role of imaging secondary to minor traumatic brain injuries and comparing understanding to those viewing the infographic. We cannot rule out that simply providing additional information (the infographic) was sufficient to increase family members' understanding.

Another study by Egan et al. (2021) evaluated the effect of infographics on public recall, sentiment, and willingness to use a face mask during the COVID-19 pandemic. Groups who viewed the infographic showed significantly higher average recall scores on the correct way to use a face mask and had greater confidence about mask-wearing as compared to the no-intervention control group. The study did not compare the infographic to a text passage containing the same information, so the effects of this approach as compared to infographics is

unknown. Comparison to a different method of education would have strengthened the conclusion that infographics are beneficial in this capacity.

A study by Ebrahimabadi et al. (2019) evaluated the impact of an infographic on health-related behaviors among 80 patients with asthma. Patients either participated in two 20-minute video presentations about medication management of asthma or received two 20-minute presentations about medication management using an infographic. An assessment of medication-taking behavior was administered prior to the intervention. Two weeks post-intervention the survey was re-administered, and both interventions statistically improved medication-taking behavior. One-month post-intervention, only the infographic group continued to demonstrate significantly enhanced medication-taking behavior. The strength of this study was having a comparator group.

In a study conducted by Harrison et al. (2020), women with gestational diabetes were invited to attend a class on gestational diabetes management; half of the women also received a paper copy of an infographic about the importance of physical activity for women with gestational diabetes. The outcomes measures were knowledge about physical activity in the face of gestational diabetes, and a self-efficacy assessment for physical activity participation. This was assessed at the end of the class, and again one week later. There was a statistically significant increase in knowledge and self-efficacy both at the end of the class, and one week later with the infographic plus class group of women. A positive aspect of the study was the efforts by investigators to assure readability and user comprehension of the infographics, similar to what was done in this study. There was no mention of a learning theory guiding the development of the infographic. It would have been interesting to also see if the inclusion of the

infographic actually led to behavior change, over and above knowledge and an increase in self-efficacy; in other words, did the infographic help change actual behavior?

From these limited number of studies, the findings suggest that infographics seem to provide a preferred reading experience, yet assessment of knowledge acquisition shows mixed results. In the area of education, there are few studies exploring the effects of infographics in pre- and health professional education. The next section reviews these studies.

### ***Pre-Professional and Graduate Health Profession Education***

There is little data investigating the use of infographics in pre-professional and graduate health profession education. This section reviews studies relevant to this research spanning various student projects and assignments in global public health, anatomy instruction, health information technology, digital literacy, and radiology education.

Caron et al. (2018) investigated the utility of infographics in demonstrating an impact on a health issue and/or encouraging a health behavior change. Students in the Health Management and Policy course “Global Public Health Issues” were tasked with choosing a health-related topic and performing a literature search. Librarians led four workshops on how to search literature, and how to create an infographic. This was a qualitative research project that garnered students’ reflections on creating an infographic (e.g., “Do you think they are effective and why? What did you find most challenging in creating an infographic?”). Students’ remarks were generally positive, and faculty found this activity led to sustainable course and content engagement, increased interaction between students and faculty, and exposed students to how to visually convey health information. There was no mention of following a specific learning theory in the creation of the infographics.

Ozdamli and Ozdal (2018) prepared an infographic on digestive anatomy for students enrolled in an anatomy course in the Physical Education and Sports Department at Near East University. This qualitative study consisted of a nine-question survey at the end of the course. The survey asked students if they had heard of infographics or seen them before, if they thought they were beneficial and improved understanding of the content, whether or not the infographic would be useful in studying, and the advantages/disadvantages of the infographic. The responses were very positive however the results did not support the researchers' conclusion that "...it can be claimed that infographics are not only more effective but also more permanent in the minds" because knowledge retention was not assessed.

Falk (2016) developed an assignment for accelerated Bachelor of Science in Nursing students to create an infographic as part of a 3-credit online course "Health, Information and Technology." Students were given the learning objectives and expectations of the assignment. They could work alone or in pairs to develop an infographic on a timely/significant public health challenge. Students received education on how to develop an infographic. The only outcome assessment was student feedback which was solicited in a discussion board thread. Based on analysis of threads, the author reported that students had a positive impression of this learning activity, expressing appreciation for the ability to use their creativity and incorporate learning from prior coursework. Several students commented on how disparate skills in infographic design between students was a disadvantage for some, and several questioned the return on investment (learning) for the time spent in this activity. Having a comparator group, including a quantitative assessment, and following good design principles would have strengthened this study.

Jones et al. (2019) used an infographics assignment to build digital skills in undergraduate social work students at three universities. Their justification for this research was the need for social workers to possess excellent digital skills, such as reaching out to communities via social media and web-based platforms to complete their professional tasks. Faculty first provided education on how to create an infographic, then students were asked to identify a research article, social work topic or legislative policy to use as the focus for an infographic they would create. Students traded their prepared infographic with a peer, and they were graded using the instructor-designed grading rubric. Students were given an opportunity to improve their infographic prior to handing in for final faculty grading. Students also reflected on this experience in a blog post or short paper. For extra credit, students were asked to anonymously complete a survey related to this project.

The majority of respondents reported being comfortable completing a technology/infographic project (average score was 6 on a 0-7 scale with 7 being very comfortable). Most respondents found the infographic assignment to be “mostly” or “very” valuable as a learning activity. Students were asked open-ended questions about what they most enjoyed about the assignment and how it compared to assignments in their other classes, and the ability to be creative was the most common response. The conclusion was students valued this assignment and said it improved their engagement and learning. No mention was made of adhering to a learning or design theory, nor any quantitative outcome assessments.

Takashima et al. (2019) evaluated the use of infographics in radiology education. Undergraduate radiology students were divided into two groups; both groups received 4 lectures on the fundamentals of radiation, exposure, and protection, but only one group was also given an

instructor-developed infographic. The results from an objective assessment after all four lectures were mixed. For two of the four lectures, those who received the infographic performed better, but not the other two lectures. Results were also different between students who had a prior background in math and science as compared to those who did not. The authors concluded the “weightiness” of the content in the four lectures, and consequently the infographic, was not equal, making it difficult to draw conclusions on the isolated impact of the infographics. This study could have been strengthened by perhaps providing a comparator job aid that was text-based to compare to the infographic recipients.

Except for the Takashima et al. study (2019), the remaining studies were qualitative in nature. The Takashima et al. study (2019) attempted to show an increase in knowledge, but the results were inconsistent. There is no consistent published experimental research demonstrating a positive change in knowledge acquisition among health professional students using an infographic model.

### ***Health Care Providers***

Much of the research on the use of infographics and practicing health care providers deals with information dissemination. For example, Ibrahim et al. (2017) points out that the *Annals of Surgery*, like other major academic research journals, have now included visual abstracts (infographics) in tweets about articles published in their journal. This study was a case-control crossover study that compared tweets with only the title of the article with tweets that contained the title and a visual abstract. The primary outcome was the number of times each tweet was seen, shared, and number of times the article link was clicked. The results showed an increase for each primary outcome, respectively, an increase of 7.7-fold for *seen*, 8.4-fold for *shared* and 2.7-

fold for *number of clicks*. A similar, but smaller study, was conducted by Barlow et al. (2020) evaluating engagement rates from tweets on a variety of published articles from one Twitter account. Their results showed a two-fold higher engagement rate when tweets contained an infographic, with an increase in retweets and “likes” when infographics were included. Of course, re-tweeting does not necessarily correlate to increased knowledge retention or transfer.

A trend in sharing research findings in scientific poster exhibitions is the inclusion of an infographic. Persky (2016) reminds us of the purpose of the scientific poster, writing, “the main purpose is to visually communicate research findings to a group of individuals with similar interests and to promote networking” (p. 1). He goes on to say that most scientific posters over-communicate, with long titles, and an over-abundance of text in small print. Also, poster session attendees decide whether to linger or not on a particular poster in about 10 seconds. Young et al. (2019) evaluated pharmacy resident’s scientific posters, comparing the traditional text-based format with an infographic-based format. The same research findings were developed in both formats, and pharmacy residents and preceptors rated the clarity and comprehensibility of both (found to be similar) and aesthetic appeal (higher for infographic poster). Residents did not have a preference between the two styles, but preceptors overwhelmingly preferred the infographic format. Some respondents felt the infographics poster lacked details provided by the text-based poster, however this could be remedied by including a QR (quick response) code that provides additional detail.

Turck et al. (2014) asked healthcare providers to compare a text abstract with an infographic abstract, asking the providers their opinion on several points. These included which format they believed was the more effective way to convey information to other healthcare

providers, which allowed a quicker, more efficient read and which would like to allow longer retention of knowledge (Turck et al., 2014). Respondents favored the infographic presentation when used in the social media context, online medical journals, drug package inserts and pharmaceutical company web sites, but preferred the traditional abstract format in a print medical journal. Respondents strongly felt the infographic was a more efficient read and would facilitate long-term knowledge retention. Knowledge retention or transfer was not assessed in this study.

Hughes et al. (2020) evaluated the gain in knowledge and preference in abstract presentation (text vs. infographic) in a surgery journal club. For the first five weeks, the traditional text abstract was displayed and served as the basis for the journal club discussion. For the second five weeks, an infographic summary was displayed in lieu of the text abstract. After the ten weeks, a 30-question quiz was administered on all ten journal articles, and performance was significantly greater on those articles where an infographic summary was displayed. Respondents were also asked to state their preference, and 80% preferred the infographic format. These results would have been even more compelling if they had rotated text and infographic format weekly, instead of giving the quiz immediately after the five weeks stretch where infographics were utilized. In this study, participants were randomized to view an infographic *or* a text medication informational leaflet for the two study medications (hydromorphone or hydroxyzine).

Interestingly, Martin et al. (2019) also compared a text abstract with an infographic summary, assessing reader preference, cognitive load and delayed information retention. After reviewing four article summaries in text and four article summaries as an infographic, the

physician respondents showed a statistically greater preference for infographics, rated the cognitive load as statistically lower, however delayed information retention was similar between the two abstract formats. This study had several strengths including having a comparator (text, in addition to an infographic), randomization in presentation (text or infographic), and participant self-evaluation of cognitive load. This study shares many of these characteristics, plus has designed the infographics using the CTML.

Beyond the use of infographics in sharing research findings, infographics have been assessed in several other practice areas. Carroll et al. (2019) used infographics that displayed prescription dispensing data with prescribers in the area, which enhanced collaboration with prescribers in many areas; prescribers received these infographic summaries very favorably. A two-page infographic on medication abortions was distributed to pharmacists in India with the intent of enhancing patient counseling (Diamond-Smith et al., 2019). A pre-post knowledge survey was distributed and showed a significant increase in pharmacist knowledge. However, when a “mystery client” (like a secret shopper) presented in the pharmacies, there was no improvement in the counseling skills of pharmacists who received the intervention as compared to the control group. The researchers concluded the translating knowledge into behavior is challenging.

Orner et al. (2020) evaluated medical residents’ perception of infographics as a tool for “Just-in-Time Teaching.” Infographics were emailed on relevant topics to residents over a six-week period, followed by a survey of the perceived usefulness of the infographics for resident teaching medical students. A focus group meeting was held to confirm survey findings. Results showed over 75% of emails were opened, with 65% engaged, and they were rated positively.

There was no data on the implementation of using the infographics, which limits the impact of this data.

While not addressing an area of healthcare, a study by Alrwele (2017) implemented more exacting methods to assess differences in academic achievement, and student perceptions when incorporating an infographic in teaching. The author went to great lengths to assure validity of the achievement test, and a questionnaire to determine students' perceptions of the infographics. All students received the same oral lectures, group discussions, and worksheets; the one difference was the control group received PowerPoint presentations, as opposed to the intervention group receiving infographics. Results showed statistically significantly better performance on the achievement test and favorable student perceptions in the intervention group.

The research studies reported in this paper often contained design flaws, such as under-powered samples, disparate numeracy and health literacy among participants, the presence of confounding variables, or did not include an equitable comparator (in other words, a non-infographic learning object covering similar content and at the same cognitive level). This study included an equitable comparator prepared at the same cognitive level.

### ***Infographic Educational Outcomes Designed with CTML***

Several studies on the educational value of infographics outside of the categories just described have stated that the CTML is an important element of infographic design (Alwadei & Mohsen, 2023; Dogomeo & Aliazas, 2022; Polowsky & Steciuch, 2020.) Alwadei and Mohsen (2023) investigated the benefits of using infographics as a teaching tool in vocabulary learning and retention among English as a foreign language student. They stated that infographic design was guided by the theory of multimedia learning, specifically citing cognitive theory and the

CTML but they did not state which, if any, of Mayer's (2021) principles were incorporated in designing the infographics. Participants who learned from the infographics (as compared to traditional instruction) did score better on vocabulary recognition knowledge and production knowledge in both the short- and long-term. There was no mention of assessing participants' cognitive load.

Polowsky and Steciuch (2020) compared knowledge acquisition about cheese making between two groups. The control group performed a traditional hands-on exercise on making mozzarella cheese while the interview group viewed an interactive infographic that illustrated the cheese-making process. While both groups showed significant increases in cheesemaking self-efficacy, the experimental group demonstrated a statistically significantly greater increase in knowledge. The authors acknowledged the CTML as a theoretical framework and were explicit about explaining how Mayer's (2021) principles of CTML were incorporated into the development of the infographic. There was no mention of assessing cognitive load during this activity.

Dogomeo and Aliazas (2022) investigated knowledge gained about scientific principles and students' perception of dual coding cognition in eighth grade students. The authors stated that the CTML and the Dual Coding theory constituted their theoretical framework for this research. The authors did not explicitly state that the infographics created on four different scientific principles incorporated any of Mayer's (2021) principles. The pre-post test of knowledge was before intervention, and after infographic exposure, with the post-test showing a statistically significant improvement. They also concluded from the Dual Coding questionnaire that students are very capable of encoding information and forming mental imagery. While this

may be interpreted as supporting the concept of cognitive processing, the authors also state this results in a reduction in cognitive load. However, these results are open to interpretation as there was no attempt to assess cognitive load (intrinsic, extraneous, and/or germane), and the statistical improvement in knowledge cannot necessarily be attributed to the use of infographics as there was no comparator (such as a reading).

A study by Martin et al. (2019) is the closest methodology to this research. In the Martin et al. study (2019) they compared participant preference, delayed information retention, and self-assessed cognitive load after reading infographic article summaries as compared to traditional text-only research abstracts. The cognitive load self-assessment used in this study was one developed by Paas (1992), which is a nine-point Likert scale answering a single question “what is your perceived invested mental effort.” This rating scale does not allow for separation of the different types of cognitive load (intrinsic, extraneous, germane), and the reliability and validity of this subjective measure is debatable (Ayres, 2018). These research findings would have been strengthened by having a comparator group (such as infographic vs. another form of intervention to serve as a control), developing the infographics according to the principles of the CTML, and administering a scale to determine all three types of cognitive load.

### **Implications for Health Professions Education and Educators**

Findings from the studies discussed in the previous section are inconsistent on whether infographics are effective multimedia learning or instructional tools for enhancing educational outcomes. Research involving the lay public or patients showed a “liking” (i.e., preference) for infographics and a self-declared better understanding of content, but assessment of knowledge recall and comprehension was mixed (Buljan et al., 2018; Damman et al., 2018; Dowling et al.,

2019; Egan et al., 2021). One study (Ebrahimabadi et al., 2019) showed better medication adherence in the group that utilized an infographic, although both the infographic and video formats may have led to an increase in adherence to medication protocols among asthma patients.

The study by Alwadei and Mohsen (2023) was conducted in a population of lay people, and the infographic did show superior knowledge retention compared to a traditional learning activity. The authors stated that learning activities were designed based on the CTML, but were not explicit, and did not assess cognitive load. The other studies that discussed basing infographic design on the CTML generally showed a favorable outcome for those given the infographic, but how the CTML was incorporated was not always made clear, and there were methodological drawbacks to several of the studies.

Health care professional trainees reported mostly positive impressions of infographics (Caron et al., 2018; Falk, 2016; Jones et al., 2019; Ozdamli & Ozdal, 2018), and the one study that assessed increase in knowledge showed mixed results (Takashima et al., 2019). Infographics have been shown to generate heightened interest in published articles when used in tweets (Barlow et al., 2020; Ibrahim et al., 2017), and infographics met with a favorable impression in scientific research posters (Young et al., 2019). Infographics were liked by journal club participants but had a mixed impact on knowledge retention (Hughes et al., 2020; Turck et al., 2014). Interestingly, use of an infographic as opposed to text was thought to reduce cognitive load in reviewing a journal citation (Martin et al., 2019).

At face value, it seems reasonable that use of an infographic in education should enhance learning and educational outcomes per the CTML. The literature reviewed in this paper,

however, does not offer conclusive evidence that this is the case. There are several explanations for this finding. First, Mayer (2021) has demonstrated 15 research-based principles for developing multimedia learning objects that aim to either reduce extraneous processing, manage essential processing or foster generative processing. None of the studies that assessed the educational impact of infographics made mention of incorporating these specific principles into the infographic design. The infographics may have been eye-catching and “liked” by learners, but they did not contain research-proven design principles. Many of the studies incorporated infographics designed by learners, which were even less likely to consider these research-developed design principles.

### **Summary**

IFCs play a significant role in caring for hospice patients, including medication management. Medication management tasks may be categorized as teamwork, organization, symptom knowledge, medication knowledge, or personhood (Lau et al., 2009). Arguably, knowledge of when and how to use the medications is the most important component of medication management. It is imperative that the hospice community find strategies to enhance IFC knowledge about commonly used medications. Unfortunately, there is no standard for educating IFCs about the use of medications, preparing them for their role in medication management, or evidence providing insight on how to optimize cognitive load regarding this learning. Further, there is little data showing best practices on how hospice programs can best prepare IFCs, although use of a theoretical or conceptual framework seems like a reasonable starting point.

Research to date has shown that infographics seem to leave a favorable impression with learners, may reduce cognitive load, but have a mixed effect on knowledge growth and retention. If this is the case, perhaps all health care professionals should learn how to generate infographics aligned to effective learning principles, to improve aspects of patient education. Additional rigorous research is needed to investigate whether the use of infographics (when designed incorporating elements shown to enhance learning according to the CTML and using rigorous research methods) results in knowledge gain. This study sought to expand the literature on the use of infographics to enhance learning outcomes, while reducing intrinsic cognitive load, reducing extraneous cognitive load, and optimizing germane cognitive load.

## **CHAPTER THREE: METHODS**

### **Introduction**

The purpose of this study was to investigate whether informal caregivers of seriously ill patients can better retain knowledge about medications when information is provided by a leaflet prepared as an infographic, as compared to a text passage written at the same reading level. This chapter presents the research design, research questions and hypotheses, participants and sampling, and a description of the development and pilot testing of the medication leaflets. Next, data collection, study procedures, and data analysis plan are presented. Definition of terms is shown in Appendix A.

### **Research Design**

To examine whether differences exist in IFC medication knowledge retention and cognitive load between the two groups, a quantitative posttest-only control group design was used with Group A as the experimental group and Group B as the control group. This design was appropriate for this study because participants were randomly assigned to either receive the intervention or not (exposure to the infographic), and the outcome of interest is measured post-intervention (Choueiry, 2021). The first dependent variable was immediate knowledge retention scores as assessed by a quiz. Cognitive load was the second dependent variable, parsed into intrinsic, extraneous, and germane cognitive load. The independent variable was format of the medication information leaflet of two types (infographic and text).

## Research Questions and Hypotheses

This study sought to answer the following research questions:

**RQ1:** Is there a statistically significant difference in knowledge retention as demonstrated by a quiz score, between participants who viewed a medication informational leaflet prepared as an infographic and participants who viewed a text passage written at the same reading level?

**H<sub>0</sub>:** There is no statistically significant difference in knowledge retention as demonstrated by a quiz score, between participants who viewed a medication informational leaflet prepared as an infographic and participants who viewed a text passage written at the same reading level.

**H<sub>1</sub>:** There is a statistically significant difference in knowledge retention as demonstrated by a quiz score, between participants who viewed a medication informational leaflet prepared as an infographic and participants who viewed a text passage written at the same reading level.

**RQ2:** Is there a statistically significant difference in cognitive load (intrinsic, extraneous, and/or germane), between participants who viewed a medication informational leaflet prepared as an infographic and participants who viewed a text passage written at the same reading level?

**H<sub>0</sub>:** There is no statistically significant difference in cognitive load (intrinsic, extraneous, and/or germane), between participants who viewed a medication informational leaflet prepared as an infographic and participants who viewed a text passage written at the same reading level.

**H<sub>1</sub>:** There is a statistically significant difference in cognitive load (intrinsic, and/or extraneous, and/or germane), between participants who viewed a medication informational leaflet prepared as an infographic and participants who viewed a text passage written at the same reading level.

## **Participants and Sampling**

The participants for this study were informal caregivers who have provided some element of medication management for patients diagnosed with a serious illness, including patients who may have been receiving hospice or palliative care services. Medication management was defined as physical handling of medications (acquiring medications, organizing medications such as pill boxes, assisting with medication administration), or cognitive activities (such as organizing and tracking medications, evaluating the patient's response to drug therapy, and making treatment decisions) (Look & Stone, 2018). Serious illness was defined as an illness that may be the cause of death.

Students enrolled in the University of Maryland, Baltimore Master of Science in Palliative Care program served as facilitators in recruiting study participants. Using a purposive sampling strategy, students were asked to identify two participants at their discretion who met the inclusion criteria. Participants could be friends, family members, neighbors, colleagues at work, or any other individual who met the inclusion criteria. It was important that the student identify two participants geographically close to the student, as the student had to be physically present with the participant during the data collection period. At the time of the study, student recruiters were physically located throughout the United States, and five of the 60 student recruiters were international (two in Africa, one each in Germany, Canada, and Kuwait).

Inclusion criteria included participant having provided medication management to a person with a serious illness, participant between 18 to 88 years of age, participant able to converse in English (based on conversations during screening) and participant had never received training in medication management or been paid as a health care provider. The age

range of 18-88 years was selected because participants under the age of 18, or over the age of 88 years are considered vulnerable populations by the University of Maryland, Baltimore Human Subjects Research IRB. No attempt was made to assess the IFCs' reading comprehension, as this is not performed in actual practice. The exclusion criteria were the IFC did not meet the inclusion criteria or was unwilling or unable to give consent to participate.

### **Development and Pilot Testing of Study Materials**

#### **Development of Infographics and Text Leaflets**

Consistent with the principle of pre-training in the CTML, a pre-training infographic leaflet was prepared. The generic and trade names of both medications used in this research (hydromorphone and hydroxyzine) were listed on the leaflet, using tall man lettering, a technique used to differentiate medications that look or sound alike (ISMP, 2019). Using this approach, the leaflet displayed the medication names as *hydroMORphone* and *hyDROXYzine*.

Medications leaflets were developed in a prior pilot project for two medications commonly used in hospice care. The two medications were hydromorphone (Dilaudid, an opioid or pain management drug), and hydroxyzine (Vistaril or Atarax, an antihistamine drug). The medications were selected because they have a similar level of lay person familiarity and complexity. The medication information leaflets were prepared as infographic leaflets (following the principles of the CTML, and as a text leaflet written at the same reading level, which was 4.6 grade level). The National Council on Prescription Medication Information (2021) has proposed ten questions every patient should ask their prescriber about each medication they are taking. Five of the questions, determined by a panel of palliative care experts (two pharmacists, two

physicians), were answered on each medication information leaflet. These specific questions were determined to be pertinent to patients with a serious illness, specifically:

1. What are the names of the medicine?
2. How does it work? How will it help me?
3. How and when do I take the medicine?
4. When will it work?
5. What are the side effects (common and serious)?

Other questions, such as how long the patient should take the medication, how the medicine should be stored, and if any additional information is available, were determined to be less important. The leaflets were prepared with answers to these five questions for both medications. Content validity was assessed by having four subject matter palliative care experts review each of the study materials (two pharmacists and two physicians). Once the content was agreed upon, drafts of the infographics and text leaflets were reviewed by a faculty member at the University of Baltimore (an expert in making medical information easier to read for people with lower literacy skills), a graphic designer faculty member at the University of Baltimore, and a faculty member at the Florida Institute of Technology (an instructional designer knowledgeable about CTML and graphic design).

As discussed in Chapter 2, Mayer (2021) has proposed 15 principles for multimedia instruction, which aim to improve learning by reducing intrinsic and extraneous cognitive load, and to maximize germane cognitive load, as follows:

- Reduce extraneous processing (the equivalent of Sweller's (2010) extrinsic cognitive load and includes coherence principle, signaling principle, redundancy principle, spatial contiguity principle, and temporal contiguity principle)

- Manage and reduce essential processing (the equivalent of Sweller’s (2010) intrinsic cognitive load which includes segmenting principle, pre-training principle, modality principle)
- Foster generative processing (the equivalent of Sweller’s (2010) germane cognitive load, which includes multimedia principle, personalization principle, voice principle, image principle, embodiment principle, immersion principles, and generative activity principle).

Table 3.1 explicitly describes how each of the seven principles was incorporated into development of the hydromorphone infographic (Appendix B) and hydroxyzine (Appendix C).

**Table 3.1**

*Use of Mayer’s (2021) CTML Principles in Designing Infographics*

Cognitive Capacity Demand Category	Implementation in Design of Infographics
Extraneous Processing (Sweller’s extraneous cognitive load)	
Coherence Principle	The coherence principle states that learners understand a multimedia lesson better when it is more concise. Both the hydromorphone and hydroxyzine infographics were critically evaluated, and any interesting but unnecessary words or pictures were eliminated. If a word or image was included simply for aesthetic purposes, but did not contribute to learning, it was eliminated.
Signaling Principle	The signaling principle states the learner’s attention should be drawn to important information. In both the hydromorphone and the hydroxyzine infographic, a stop sign was inserted in the section titled “Serious Side Effects? Call Your Nurse.” The stop sign is also in a bright, eye-catching color.
Spatial Contiguity Principle	The spatial contiguity principle states that words and pictures should be placed next to each other. Very specific pictures were selected to mirror the meaning of the words, such as a graphic of a person swallowing a teaspoonful of medication, directly next to the words “take it by mouth.” There is a graphic of a toilet directly next to the word “constipation,” a side effect of hydromorphone. On the hydroxyzine infographic, there is a clock image next to the three bullet points about how quickly the medication works.

Table 3.1 continued on next page

Essential Processing (Sweller's intrinsic cognitive load)	
Segmenting Principle	The segmenting principles states that learners perform better when multimedia is presented in user-paced segments as opposed to a continuous flow of information. This was implemented in infographic design by having bright, colorful headers at the top of each section, conveying a sense of segments.
Pre-training Principle	An infographic was designed listing the two medications that were used in this research (hydromorphone and hydroxyzine). The generic and trade names were provided. The generic names were written using tall man lettering, a strategy used to differentiate between look-alike, sound-alike drugs. The purpose of this pre-training was to define the two medications used in the study, and to illustrate that they are different medications.
Generative Processing (Sweller's germane cognitive load)	
Personalization Principle	The personalization principle explains that learners perform better when words are used in a conversational fashion instead of more formal presentation. One simple way the infographics were made more personal was to direct the learner to "call YOUR nurse" instead of "call THE nurse" in the event an adverse event occurred after taking the medication.
Generative Activity Principle	The generative activity principle states that individuals learn better when applying newly learned information. This was operationalized in this research by quizzing the learner about each infographic.

When the faculty and experts were all in agreement regarding the content, the equivalent reading level, and adherence to CTML, a graphic designer (easel.ly) was hired to finalize the infographic versions of the hydromorphone and hydroxyzine leaflets for the study, adhering to the mock-up provided. The final, agreed-upon study materials included an infographic leaflet on hydromorphone, a text leaflet on hydromorphone (same reading level), an infographic leaflet on hydroxyzine, and a text leaflet on hydroxyzine (same reading level).

### **Pilot Testing Medication Informational Leaflets and Quizzes**

The medication informational leaflets were pilot tested at the University of Baltimore User Research Lab, under the direction of the lab director, Dr. Kathryn Summers. Five participants were invited to the lab and asked to view all medication informational leaflets. Four

of the participants had a reading level of 5th-8th grade, and the remaining participant had a reading level of 3rd-4th grade. Each participant was advised to study each leaflet as long as they felt it necessary to grasp the information. None of the participants exceeded 90 seconds of observation. Participants were asked to explain each medication information leaflet aloud, and Dr. Summers gauged their apparent comprehension based on her experience, concluding that each leaflet was acceptable. Participants also completed a knowledge assessment on the medication informational leaflet they viewed, and no participants required greater than 2 minutes to complete the quiz to the best of their ability. Participants were asked to provide feedback on the readability and understandability of the quizzes.

### **Data Collection**

Three instruments were used to collect data in this study. The first solicited participant sociodemographic information, second was a medication information quiz, and third was a cognitive load assessment.

### **Demographic Information**

After reading and hearing the explanation of the project (verbal consent) (Appendix D), participants completed a sociodemographic survey that queried age, gender, highest level of education completed, race and native English-speaking status (Appendix E). Race categories were taken from the US Census Bureau surveys (U.S. Census Bureau, 2023).

### **Medication Knowledge Assessment**

After completing the demographics survey, viewing the pre-training infographic (Appendix E), and viewing a medication informational leaflet (Appendices B, C, G, H), participants completed a medication knowledge assessment (Appendix I and J). There were five

write-in response questions for the hydromorphone quiz (Appendix I) and six write-in questions for the hydroxyzine quiz (Appendix J), each totaling a maximum of 10 points. As discussed previously, four subject matter palliative care experts assessed content validity.

### **Cognitive Load Assessment**

After completing the knowledge assessment, the participants completed a two-part Cognitive Load survey (Appendices J and K). Part I included specific questions adapted with permission from a validated survey (Andersen & Makransky, 2021) (Appendix K). Part II was a global rating scale adapted from a second validated survey (Sewell et al., 2016) (Appendix L). This global rating scale has one item each for intrinsic, extrinsic, and germane cognitive load. The ratings from the global rating scale would be used if the adapted questions in Part I did not achieve a satisfactory Cronbach's alpha for this research. Andersen and Makransky (2021) adapted a cognitive load scale from Leppink et al. (2013) and expanded it to assess both physical and online teaching environments.

Anderson and Makransky (2021) conducted several studies to validate their adaptation and expansion of this model. For example, the model that exemplified proof of valid and reliable measurement was a study conducted at a European University with students in a psychology course. They administered their adapted survey which consisted of a series of statements that participants rated, reflecting their intrinsic, extraneous, and germane cognitive load. The reliability of the scale was demonstrated with a Cronbach's Alpha of 0.89. They also conducted a confirmatory factor analysis which achieved acceptable fit values (confirmatory factor analysis of 0.999, Tucker Lewis Index of 0.999, Root Mean Square Error of Approximately was  $< 0.001$

and Standardized Room Mean Residual was 0.041). The researchers concluded their model was acceptable.

The Andersen model (Andersen & Makransky, 2021) was modified for this research to reflect the content of the learning activity. The cognitive load assessment instrument used in this research also queried intrinsic cognitive load, extrinsic cognitive load, and germane cognitive load separately with several questions per domain (three for intrinsic load, seven for extrinsic load, and four for germane load) (Appendix K). A comparison of the original cognitive load assessment items published by Andersen and Makransky (2021) and Sewell et al., (2016), and the adaptations for this research are shown in Appendix M. Intrinsic cognitive load was assessed with questions 1, 2, 5 and 10 from the Cognitive Load Assessment, page 1 (Appendix K). Using all four questions the Cronbach's alpha was 0.594; eliminating question 2 increased the Cronbach's alpha to 0.605. Cronbach's alpha measures the internal consistency of an assessment instrument, and a value of 0.6 to 0.8 is considered to be acceptable (Cronbach, 1951; Frost, 2022; Hajjar, 2018; Raharjanti et al. 2022). Consequently, the total scores from questions 1, 5 and 10 were used to determine the effect of medication leaflet format on intrinsic load.

Extraneous cognitive load was assessed with questions 3, 6, 8, 11, 12, and 14 from the Cognitive Load Assessment, page 1 (Appendix K). Using all six questions the Cronbach's alpha was 0.827; therefore, the total of all six questions was used to determine the effect of medication leaflet format on extraneous load. Germane cognitive load was assessed with questions 4, 7, 9, and 13 from the Cognitive Load Assessment, page 1 (Appendix K). Using all four questions the Cronbach's alpha was 0.844; therefore, the total score for all four questions was used to determine the effect of medication leaflet format on germane load. Because the Cronbach's alpha

was acceptable (0.6 or higher) for all three types of cognitive load, there was no need to use the global cognitive load scores (van Griethuijsen et al., 2015).

### **Procedures**

Prior to data collection, the University of Maryland Baltimore Institutional Review Board approved this study (see Appendix N). Subsequently student facilitators contacted potential participants in person, by phone or by email at their discretion. The data collection instruments were mailed to each student; one packet for the participant who would be viewing the infographic medication information leaflets, and one packet for participant who would be viewing the text medication information leaflets. Students were directed to an online shared document to schedule a thirty-minute session for data collection between January 3, 2023, and January 13, 2023. At the appointed date/time, all students and participants scheduled at that time joined a video conference with me. The student read the verbal consent form to assure the participant was willing to participate and met the inclusion criteria, and I reviewed verbal consent and provided instructions to all participants, using the same script for every student/participant encounter (Appendix D). During the consent process, participants were advised that participation in this study would take approximately 30 minutes.

The data collection procedure is illustrated in Figure 3.1. Students were asked to randomly assign a packet to each participant. In Phase 1, all participants read and heard the informed consent, completed the demographics survey, and received pre-training (introduced to the two medication names). In Phase 2, participants were randomly given one of the packets previously mailed to the student. Those in Group A (experimental) viewed the infographic about hydromorphone (Appendix B). Participants randomized to Group B (control) viewed the text

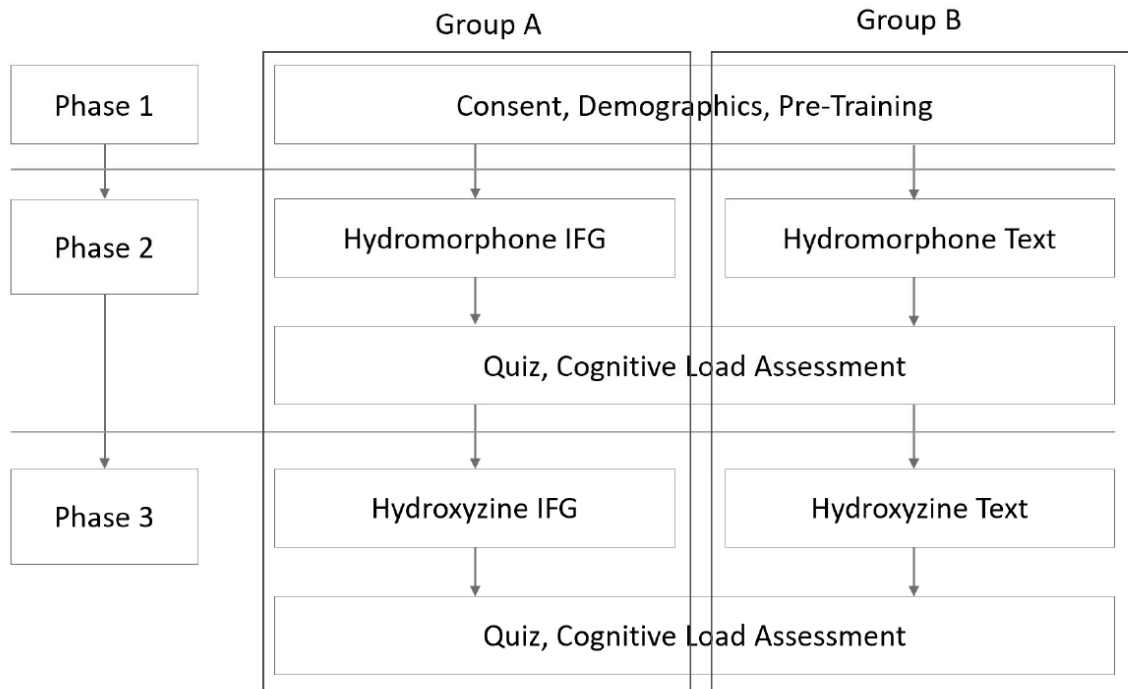
leaflet on hydromorphone (Appendix G). Ninety seconds were allowed for viewing the medication informational leaflet. After 90 seconds, the participant was instructed to go to the next page and complete the hydromorphone knowledge assessment (Appendix H). Participants were allowed up to two minutes to complete the assessment. No participants requested extra time to view the medication information leaflet or to complete the quiz. After completing the knowledge assessment, participants received a brief explanation of the two cognitive load surveys (Appendices K and L) and were instructed to complete the surveys. There was no time limit to complete the cognitive load surveys, but all participants completed the surveys in less than 5 minutes.

Phase 3 was a confirmation of Phase 2, using a different study medication (hydroxyzine). The experimental group again viewed the infographic version of the medication informational leaflet (Appendix B), then completed the knowledge assessment and cognitive load surveys. The control group B viewed the text version of the medication informational leaflet (Appendix H), and completed the knowledge assessment (Appendix J), and cognitive load surveys (Appendices K and L). Completing all three phases did not exceed 30 minutes for each participant. After collecting all data, the student scanned and emailed me all completed instruments and postal mailed the originals as well. I graded the knowledge assessments on a 0–10-point scale. Approximately one-third of completes quizzes were also graded independently by a member of the expert panel, and a kappa statistic was calculated to assure inter-rater reliability indicating almost perfect agreement ( $\kappa = .95$ ). Grading keys are shown in Appendix O and Appendix P.

**Figure 3.1**

*Data Collection with Groups Shown*

IFG = infographic



**Data Analysis**

For the research question one, independent samples t-tests were conducted for the quiz scores for each medication separately (hydromorphone and hydroxyzine), and for the summed quiz scores. An independent samples t-test was used for this question because it determines if a statistically significant difference exists between the means of two independent groups (unrelated groups with different participants providing scores for each group) (Laerd Statistics, 2020a). The second research question was analyzed using a one-way multivariate analysis of variance (MANOVA). A MANOVA was appropriate for this question because it is used to determine if there are any differences between two or more independent groups of a categorical independent

variable in terms of two or more continuous dependent variables (Laerd Statistics, 2020b). In this research, there are two groups for the independent variable (infographic and text medication information leaflets) and there are three dependent variables; intrinsic cognitive load, extraneous cognitive load, and germane cognitive load.

Descriptive analyses for participant demographics and study variables were conducted including the mean and standard deviation for quiz scores and cognitive load. Bivariate analyses were conducted for demographic variables shown to influence informal caregiver performance in medication management. Specifically, a one-way analysis of variance (ANOVA) was conducted for the independent variables, participant age and educational level, and the dependent variable summed quiz score. Independent samples t-tests were conducted for the independent variables, English-speaking status and gender, and the dependent variable summed quiz score.

Data screening was conducted on the dependent variables (quiz score, intrinsic cognitive load, extraneous cognitive load, and germane cognitive load). The data for each variable was sorted and reviewed for inconsistencies. Box plots were created for the quiz scores by format for each phase of the study including the hydromorphone quiz (Phase 2), the hydroxyzine quiz (Phase 3), and the summed quiz score (hydromorphone plus hydroxyzine).

An independent samples t-test requires testing for independence of scores and the assumptions of normality and homogeneity of variance. Normality was assessed using the Kolmogorov-Smirnov test due to the group samples sizes being larger than 50 (Mishra et al., 2019). Homogeneity of variance was tested using the Levene's test to assess whether the two groups had equal variances. The MANOVA requires several assumptions to be met including two or more continuous dependent variables, two or more categorical independent groups,

independence of observations, adequate sample size, normality, no univariate or multivariate outliers, absence of multicollinearity, linearity, and homogeneity of variance-covariance.

Adequate sample size was confirmed as there should be at least one participant per dependent variable in each group of the independent variable (Laerd Statistics, 2020c). The Kolmogorov-Smirnov test and Q-Q plots were used to assess normality. Box plots were used to detect univariate outliers for each type of cognitive load, and the Mahalanobis value was used to detect multivariate outliers.

The assumption of no multicollinearity, meaning dependent variables are reasonably correlated with each other, but not excessively correlated was assessed using a Pearson correlation coefficient, with the goal being  $<.09$  (Laerd Statistics, 2020c). The assumption of linearity between dependent variables and each independent variable was assessed by visualizing a scatterplot matrix, and observing if there is a straight or curved line. Lastly, the assumption of homogeneity of variance-covariance was tested using the Box's M test (Box's Test for Equivalence of Covariance Matrices) (Glen, 2023). All data analyses was performed using IBM SPSS Statistics Version 29. The null hypotheses of this study were rejected at the 95% confidence level with  $\alpha = .05$ , while the effect sizes were reported using Cohen's d for the independent samples t-test, and partial eta squared ( $\eta^2$ ) for the analysis of variance and multivariate analysis of variance.

## CHAPTER FOUR: FINDINGS

### Introduction

This study sought to investigate the impact of medication information delivery format on immediate retention of medication information and cognitive load of IFCs. This chapter includes data screening, descriptive statistics, assumption testing, bivariate analyses, and results from the main analyses. Research findings are organized by the research questions.

### Data Screening

Data screening was conducted on the dependent variables (quiz score, intrinsic cognitive load, extraneous cognitive load, and germane cognitive load). No data errors or inconsistencies were noted for any of the dependent variables. In the analysis for quiz score by format, several outliers were identified using box plots. This includes three outliers in the infographic group who scored lower on the hydromorphone quiz (see Figure Q.1, Appendix Q), one outlier in the text group who scored lower on the hydroxyzine quiz (Figure Q.2), and the same outlier in the text group who scored lower on the quiz when the hydromorphone and hydroxyzine scores were combined (Figure Q.3). The analysis was run with the outliers removed to determine whether removal was required; the results were unchanged and remained statistically significant. Therefore, these outliers were included in the final analysis (Gall et al., 2007).

Similarly, box plots were generated for intrinsic load (Figure Q.4), extraneous load (Figure Q.5), and germane load (Figure Q.6) by format. Five outliers were identified and removed from the sample. However, with removal of these five outliers, the maximum Mahalanobis value (17.88) exceeded the critical value (16.27). On closer inspection there was one variable with a  $p$  value  $< .001$ . Once that one case was removed from the model, the

maximum Mahalanobis value (14.76) fell below the critical value (16.27) (Laerd Statistics (2020d).

## **Descriptive Statistics**

### **Participant Demographics**

Sixty student facilitators were charged with identifying two qualifying participants. All students were successful, yielding a total of 120 participants. All 120 completed the study; half (60) were in the experimental group (Group A – infographic leaflet exposure) and 60 were in the control group (Group B – text leaflet exposure). The sociodemographic characteristics of both groups, and the entire sample, are shown in Table 4.1. Seventy percent of informal caregivers in the total cohort were women (65% of participants in Group A, and 75% of participants in Group B). There was a wide range of participant ages, ranging from 18 years to 88 years of age, and all age categories were represented in both cohorts. Specifically, 48.3% of Group A participants were age 50 years or older, while 56.6% of Group B participants were age 50 years or older. Of the entire cohort, 77.5% of participants were age 64 years or younger.

Educational background ranged from “did not graduate high school or GED” to “graduate degree” in both groups. Of the entire cohort, 63.4% earned some kind of college degree (Associate, Baccalaureate, or Graduate degree). There were more caregivers in Group B with a college degree (68.3%) than Group A (58.3%). The majority of caregivers in the total cohort were white individuals (80%). The remaining 20% of caregivers had representation in all remaining groups. The majority of participants were native English speakers (87.5), with the remainder being non-native English speakers.

**Table 4.1***Sociodemographic Characteristics of Participants*

Characteristic	Experimental Group (IFG)		Control Group (Text)		Entire Sample	
	n	%	n	%	n	%
<b>Gender</b>						
Female	39	65.0	45	75.0	84	70.0
Male	21	35.0	15	25.0	36	30.0
<b>Age</b>						
18 to < 30 years	10	16.7	7	11.7	17	14.2
30 to < 50 years	21	35.0	19	31.7	40	33.3
50 to < 65 years	21	35.0	15	25.0	36	30.0
65 to < 80 years	6	10.0	17	28.3	23	19.2
80 – 88 years	2	3.3	2	3.3	4	3.3
<b>Education</b>						
Did not graduate high school or GED	2	3.3	1	1.7	3	2.5
High school or GED	11	18.3	9	15.0	20	16.7
Some college, no degree	12	20.0	9	15.0	21	17.5
Associate Degree	3	5.0	6	10.0	9	7.5
Baccalaureate	15	25.0	17	28.3	32	26.7
<b>Degree</b>						
Graduate Degree	17	28.3	18	30.0	35	29.2
<b>Ethnicity</b>						
American Indian or Alaska Native	0	0	1	1.7	1	0.8
Asian	4	6.7	6	10.0	10	8.3
Black or African American	5	8.3	7	11.7	12	10.0
Native Hawaiian or other Pacific Islander	0	0	1	1.7	1	0.8
White	51	85.0	45	75.0	96	80.0
Prefer not to disclose	0	0	0	0	0	0.0
<b>English Speaking</b>						
Native English Speaker	54	90.0	51	85.0	105	87.5
Non-native English Speaker	6	10.0	9	15.0	15	12.5

## Study Variables

Quiz scores for Phase 2 (hydromorphone) ranged from 1 to 10 points (out of 10 points) in Group A (infographic) and from 0 to 8 points in Group B (text) (Table R.1, Appendix R). The mean quiz score was higher in Group A ( $M = 6.7$ ,  $SD = 1.9$ ; infographic) than Group B ( $M = 5.4$ ,  $SD = 1.7$ ; text). Quiz scores for Phase 3 (hydroxyzine) ranged from 4 to 10 points in Group A (infographic) and from 0 to 10 points in Group B (text). The mean quiz score was higher in Group A ( $M = 7.9$ ,  $SD = 1.8$ ; infographic) than Group B ( $M = 6.1$ ,  $SD = 2.2$ ; text) (Table R.2, Appendix R). The quiz scores for Phases 2 and 3 (hydromorphone and hydroxyzine) were summed for each group and compared by format. Quiz scores for Group A (infographic) ranged from 6 to 20; quiz scores for Group B (text) ranged from 0 to 18. The mean quiz score was higher in Group A ( $M = 14.6$ ,  $SD = 3.2$ ; infographic), than Group B ( $M = 11.5$ ,  $SD = 3.6$ ; text). (Table R.3, Appendix R).

Similarly, descriptive statistics were obtained on total intrinsic cognitive load (Table R.10), total extraneous cognitive load (Table R.11, Appendix R), and total germane cognitive load (Table R.12, Appendix R). Participants who viewed the infographic medication leaflet scored lower than participants who viewed the text medication leaflet in intrinsic cognitive load ( $M = 16.48$ ,  $SD = 13.66$ ; and  $M = 22.59$ ,  $SD = 15.88$ , respectively). Total intrinsic cognitive load scores ranged from 0 to 50 for the infographic leaflet, and 0 to 54 for the text leaflet. Similarly, participants who viewed the infographic medication leaflet scored lower than participants who viewed the text medication leaflet in extraneous cognitive load ( $M = 15.14$ ,  $SD = 19.22$ ;  $M = 26.26$ ,  $SD = 30.65$ , respectively). Summed extraneous cognitive load scores ranged from 0 to 67 for the infographic leaflet, and 0 to 106 for the text leaflet. Participants who viewed the

infographic medication leaflet scored higher on germane cognitive load than participants who viewed the text medication leaflet ( $M = 79.64$ ,  $SD = 25.02$ ; and  $M = 68.98$ ,  $SD = 28.02$ , respectively). Summed germane cognitive load scores ranged from 14 to 110 with the infographic leaflet, and from 0 to 114 for the text leaflet. These data are summarized in Table 4.2.

**Table 4.2**

*Impact of Format on Cognitive Loads*

	Infographic Leaflet		Text Leaflet	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
Intrinsic Cognitive Load	16.48	13.66	22.59	15.88
Extraneous Cognitive Load	15.14	19.22	26.26	30.65
Germane Cognitive Load	79.64	25.02	68.98	28.02

### **Research Question 1**

An independent sample t-test was conducted to examine whether there was a statistically significant difference in knowledge retention as demonstrated by a quiz score, after viewing a medication informational leaflet prepared as an infographic as compared to a text passage written at the same reading level.

#### **Assumption Testing: Independence of Scores, Normality, and Homogeneity of Variance**

The assumption of independence of scores was met as no participants were in both groups. The Kolmogorov-Smirnov assumption of normality was not met with the hydromorphone quiz administered after viewing the infographic leaflet ( $p < .001$ ) or the text

leaflet ( $p = .02$ ) (see Table R.4, Appendix R). Similarly, the assumption of normality was not met with the hydroxyzine quiz administered after viewing the infographic leaflet ( $p < .001$ ) or text leaflet ( $p < .001$ ) (see Table R.5). The assumption of normality was met for the summed quiz score after viewing the infographic leaflet ( $p = .200$ ) but not after viewing the text leaflet ( $p = .008$ ) (see Table R.6). Le Cessie et al. (2020) state that “The t-test is not afraid of non-normal data. When there are more than about 25 observations per group and no extreme outliers, the t-test works well even for moderately skewed distributions of the outcome variable” (p. E1). There were 60 participants per treatment category in this research, exceeding the 25 recommended observations by a large margin. The assumption of homogeneity of variance was met for the hydromorphone quiz scores ( $p = .91$ ), the hydroxyzine quiz scores ( $p = .11$ ), and summed scores ( $p = .51$ ). Results are shown in tables R.7, R.8, and R.9, respectively.

## Results

The mean difference for the hydromorphone quiz scores between the two groups (infographic vs. text) was statistically significant,  $t(118) = -3.89, p < .001, d = -.710, 95\% \text{ CI } [-1.96, -.638]$ . The null hypothesis for Phase 2 was rejected as statistical significance was achieved with a medium effect size of .71. Similarly, the mean difference for the hydroxyzine quiz scores between the two groups was statistically significant,  $t(118) = -5.0, p < .001, d = -.91, 95\% \text{ CI } [-2.56, -1.11]$ . The null hypothesis for Phase 3 was rejected as statistical significance was achieved with a large effect size of .91. With regard to the summed quiz scores, the mean difference between the two groups was statistically significant,  $t(118) = -5.1, p < .001, d = .92, 95\% \text{ CI } [-4.36, -1.91]$ . The null hypothesis for the summed quiz score was rejected as statistical

significance was achieved with a large effect size of .92. A comparison of quiz scores by medication and format is shown in Table 4.3.

**Table 4.3**

*Question 1: Comparison of Text vs. Infographic Medication Information Leaflet on Quiz*

*Performance*

Quiz Performance in Phases 2 and 3	Group A Infographic Leaflet		Group B Text Leaflet		<i>t</i> (118)	<i>p</i>	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Phase 2 – Hydromorphone Leaflet (Equal variance assumed)	6.7	1.91	5.4	1.74	-3.89	<.001*	-.71
Phase 3 – Hydroxyzine Leaflet (Equal variance assumed)	7.9	1.76	6.1	2.22	-5.0	<.001*	-.91
Phase 2 (Hydromorphone) plus Phase 3 (Hydroxyzine) Summed Score (Equal variance assumed)	14.58	3.24	11.45	3.55	-5.1	<.001*	-.92

\*Statistically significant,  $p < .001$

Bivariate analyses were conducted for demographic variables that have been shown in the literature to have an impact on IFC performance in medication management. These include participant age, educational level, English-speaking status, and gender. A one-way ANOVA was performed to compare the effect of age on quiz score. Findings revealed that there was a statistically significant difference in quiz score between at least two groups ( $F(4, 115) = 5.13, p < .001, \eta^2 = .15$ ). A Tukey's HSD Test for multiple comparisons found that the mean value of quiz scores was significantly different between ages 30 to < 50 and 65 to < 80 ( $p < .001, 95\% \text{ CI} = [1.46, 6.53]$ ), and between ages 50 to < 65 and 65 to < 80 ( $p = .037, 95\% \text{ CI} = [.10, 5.27]$ ).

A one-way ANOVA was performed to compare the effect of level of education on quiz score. The findings revealed that there was a statistically significant difference in quiz score between at least two groups ( $F(5, 114) = 3.21, p = .009, \eta^2 = .12$ ). A Tukey's HSD Test for multiple comparisons found that the mean value of quiz scores was significantly different between "high school or GED" and "graduate degree" ( $p = .037, 95\% \text{ CI} = [.04, -5.9]$ ). Participants who were native English-speakers scored higher on the summed quiz score ( $M = 13.3, SD = 3.6$ ) than participants who were not native English speakers ( $M = 19.3, SD = 4.2$ ). The mean difference was statistically significant,  $t(118) = 2.4, p = .02, d = .65, 95\% \text{ CI} = [.10, 1.2]$ . Male participants scored higher on the summed quiz score ( $M = 13.2, SD = 3.5$ ) than female participants ( $M = 12.9, SD = 3.8$ ). The mean difference was not significant,  $t(118) = 0.34, p = .734, d = .07, 95\% \text{ CI} = [-0.32, 0.46]$ .

## **Research Question 2**

A one-way multivariate analysis of variance (MANOVA) was conducted to examine whether there was a statistically significant difference in cognitive load (intrinsic, extraneous, and/or germane), between participants viewing a medication informational leaflet prepared as an infographic versus a text passage written at the same reading level.

### **Assumption Testing**

#### ***Assumptions 1, 2 and 3: Variables and independence of observations***

Assumptions 1, 2 and 3 were met as there are three continuous dependent variables (intrinsic cognitive load, extraneous cognitive load, and germane cognitive load), and one independent variable with two categories. This research met the assumption of independence of observations as no participants were in both the text and infographic group.

***Assumption 4: No univariate or multivariate outliers***

As discussed earlier, a univariate analysis was conducted by creating box plots for each type of cognitive load (intrinsic, extraneous, and germane) by format and five outliers were identified and removed from the sample. One additional outlier was removed in the multivariate analysis, allowing the Mahalanobis value to fall below the critical value. Thus, this assumption was met.

***Assumption 5: Normal distribution***

The Kolmogorov-Smirnov test was used for multivariate normality. Values for Kolmogorov-Smirnov specifically showed significance for all values with the exception of total germane cognitive load and format. Results are shown in Tables R.13, R.14, and R.15 (Appendix R). Other researchers have suggested that normal Q-Q plots may verify distribution normality (Laerd Statistics, 2020c). The normal Q-Q plots for all three cognitive loads were approximately normally distributed (See Figures Q.7 – Q.12, Appendix Q).

***Assumption 6: No Multicollinearity***

It would be ideal to have dependent variables moderately correlated with each other, but not excessively correlated. As shown in Table 4.4, the Pearson correlation coefficient between dependent variables was  $<0.9$  (Laerd Statistics, 2020c).

**Table 4.4***Pearson Correlation Values*

		Total Intrinsic Cognitive Load	Total Extraneous Cognitive Load	Total Germane Cognitive Load
Total Intrinsic Cognitive Load	Pearson	1	.379*	-.030
	Correlation Significant (2- tails)		<.001	.755
	N	114	114	114
Total Extraneous Cognitive Load	Pearson	.379*	1	.368*
	Correlation Significant (2- tails)	<.001		<.001
	N	114	114	114
Total Germane Cognitive Load	Pearson	-.030	-.368*	1
	Correlation Significant (2- tails)	.755	<.001	
	N	114	114	114

\*Correlation is significant at the 0.01 level (2-tailed)

***Assumption 7: Linear relationship between dependent variables for each group of the independent variable***

Linearity between dependent variables and each independent variable may be assessed by visualizing a scatterplot matrix, and observing if there is a straight or curved line. As shown in Figures Q.13 – Q.18 (Appendix Q), a straight line was observed in each relationship between the three cognitive loads, by format. The relationship between intrinsic cognitive load and germane cognitive load demonstrated a straight line, but a somewhat weaker relationship.

***Assumption 8: Adequate Sample Size***

The sample size exceeded the minimum requirement of having at least one participant per dependent variable in each group of the independent variable (Laerd Statistics, 2020c). The G\*Power analysis showed a sample size of 51 participants per group would be required for a

medium effect size, or 21 per group for a large effect size. After removal of outliers, there were 58 participants who reviewed the text leaflets, and 56 participants who reviewed the infographic leaflets.

***Assumptions 9 and 10: Homogeneity of Variance-Covariance Matrices***

There were mixed results with the Levene’s Test of Equality of Error Variances for this study as shown in Table 4.5. Equal variances are not assumed with total intrinsic cognitive load and total extraneous cognitive load but are with extraneous germane load.

**Table 4.5**

*Levene’s Test of Equality of Error Variances*

		Levene Statistic	<i>df</i> 1	<i>df</i> 2	Sig.
Total	Based on Mean	4.13	1	112	.044
Intrinsic	Based on Median	3.42	1	112	.067
Cognitive	Based on median and	3.43	1	112	.067
Load	with adjusted <i>df</i>				
	Based on trimmed mean	4.26	1	112	.041
Total	Based on Mean	16.4	1	112	<.001
Extraneous	Based on Median	5.67	1	112	.019
Cognitive	Based on median and	5.67	1	94.6	.019
Load	with adjusted <i>df</i>				
	Based on trimmed mean	13.8	1	112	<.001
Total	Based on Mean	.39	1	112	.535
Germane	Based on Median	.58	1	112	.448
Cognitive	Based on median and	.58	1	111.46	.448
Load	with adjusted <i>df</i>				
	Based on trimmed mean	.46	1	112	.500

As shown in Table 4.6, there was homogeneity of variance-covariances, as assessed by the Box’s test of equality of covariance matrices ( $p = .020$ ).

**Table 4.6***Box's Test of Equality of Covariance Matrices*

Box's M	15.47
F	2.50
df1	6
df2	90575.13
Sig.	.020

**Results**

The differences between the format on the combined dependent variables was statistically significant,  $F(3, 110) = 3.39$ ,  $p = .021$ ; Wilks'  $\lambda = .92$ , partial  $\eta^2 = .09$ . Format had a significant effect on all three cognitive loads including intrinsic cognitive load ( $F(1, 112) = 1061.57$ ;  $p = .030$ ; partial  $\eta^2 = .04$ ), extraneous load ( $F(1, 112) = 3520.38$ ;  $p = .023$ ; partial  $\eta^2 = .045$ ), and germane load ( $F(1, 112) = 3237.68$ ;  $p = .035$ ; partial  $\eta^2 = .039$ ). Therefore, the null hypothesis was rejected. Pairwise comparisons are shown in Table 4.7.

**Table 4.7***Pairwise Comparisons*

Dependent Variable	Format	Format	Mean Difference*	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Total Intrinsic Cognitive Load	Text	Infographic	6.10	2.78	.030	.60	11.61
	Infographic	Text	-6.10	2.78	.030	-11.61	-.60
Total Extraneous Cognitive Load	Text	Infographic	11.12	4.81	.023	1.60	20.65
	Infographic	Text	-11.12	4.81	.023	-20.65	-1.60
Total Germane Cognitive Load	Text	Infographic	-10.66	4.98	.035	-20.53	-.79
	Infographic	Text	10.66	4.98	.035	.79	20.53

\* The mean difference is significant at the .05 level

### Summary

This chapter presented the results of this research study. The findings showed that the difference in knowledge retention in Phase 2 (hydromorphone) and Phase 3 (hydroxyzine) was statistically significantly difference between the experimental group (infographic medication leaflet) and the control group (text leaflet) ( $p < .001$  in both cases). Even though both groups scored higher on the second drug (hydroxyzine) than the first drug (hydromorphone), the infographic format outperformed the text format. Similarly, there was a statistically significant difference in the summed quiz score between the experimental group and the control group. The null hypothesis for both Phase 2 and Phase 3, and summed quiz scores for Question 1 was rejected.

For Question 2, there was a statistically significant difference in the cognitive load between the experimental group and the control group for all three types of individual cognitive load (intrinsic, extraneous, and germane). The null hypothesis was rejected. Most importantly, those who viewed the infographic had lower intrinsic and extraneous loads, and a higher germane load. As stated earlier, these are desirable outcomes; reducing intrinsic load reduces the inherent difficulty of the learning activity. Reducing extraneous load means we have reduced distractions not necessary for learning. Increasing and optimizing germane cognitive load results in more efficient learning.

## CHAPTER FIVE: DISCUSSION

### Introduction

In this chapter, the findings of this research will be interpreted within the context of prior studies to assess consistency of results and discuss how these findings can inform and advance the CTML, particularly for IFC medication knowledge. Implications of the study on practice (both the practice of education and the practice of educating IFCs) are discussed, highlighting how this study adds to the existing body of knowledge. Lastly, the limitations of this research will be discussed, as well as recommendations for future research.

### Interpretation of the Findings

The population of IFCs in this research approximates data reported by the National Alliance for Caregiving (NAC, 2020) in their publication “Caregiving in the US 2020.” A comparison of demographics in their 2020 report (interviewed 1,392 IFCs) and participants in this research (120 IFCs) is shown in table 5.1. The similarity between the population of IFCs and study sample is important because it increases the generalizability of findings to other IFCs.

**Table 5.1**

*Comparison of Sociodemographic Characteristics*

Characteristic	National Alliance for Caregiving (NAC, 2020)	Present Research (2023)
Gender		
Female	61%	70%
Male	39%	30%
Ethnicity		
White + Hispanic/Latino	78%	80%
Black or African American	14%	10.0%
Asian	5%	8.3%
Other	3%	2.5%

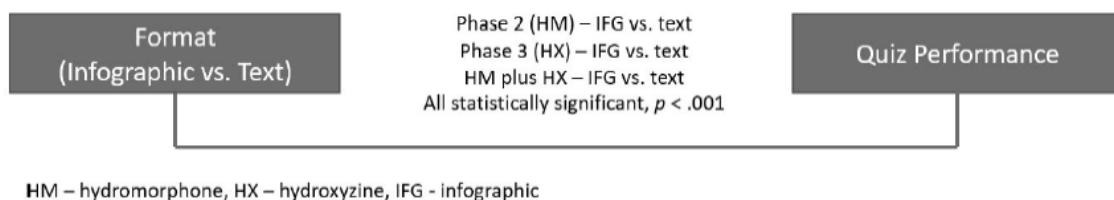
## Research Question 1

The first research question was “is there a statistically significant difference in knowledge retention as demonstrated by a quiz score, after viewing a medication informational leaflet prepared as an infographic (adhering to design principles of the CTML) versus a text passage written at the same reading level?”

The results from the independent samples t-tests showed that the scores for participants who viewed the infographic leaflet (hydromorphone alone, hydroxyzine alone, hydromorphone plus hydroxyzine) were statistically significantly higher than the scores for participants who took the same quizzes after viewing the text leaflets. The null hypothesis was rejected because format did make a significant difference in quiz score. This is illustrated graphically in Figure 5.1.

**Figure 5.1**

*Effect of format (IFG vs. text) (independent variable) on quiz performance (dependent variable)*

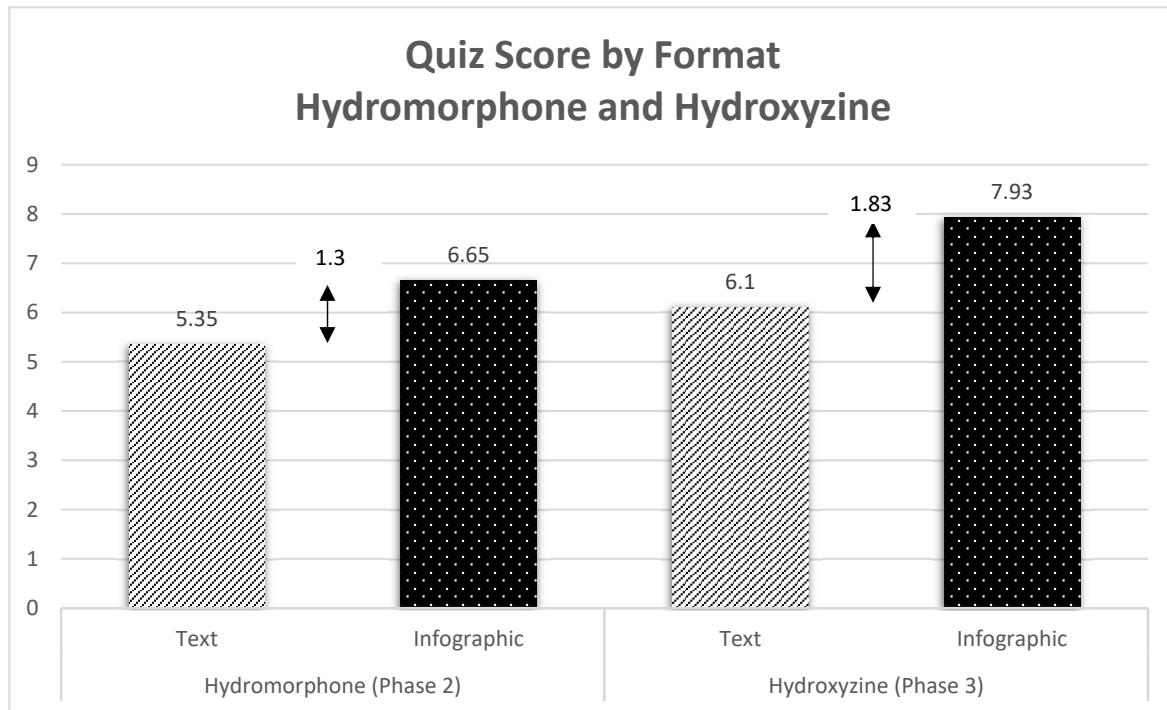


Interestingly, the mean scores for both Groups (infographic and text) were higher in Phase 3 vs. Phase 2, however the difference in quiz performance remained statistically significantly different between the two formats, in favor of the infographic. In Phase 2 (hydromorphone) there was a 1.3-point difference in favor of the IFG (representing a 24.3% increase in quiz score). In Phase 3 (hydroxyzine) there was a 1.83-point difference in favor of the

IFG (representing a 30% increase in quiz score). The difference between Phase 2 and Phase 3 quiz performance is shown graphically in Figure 5.2.

**Figure 5.2**

*Quiz Score by Format (Hydromorphone [Phase 2] and Hydroxyzine [Phase 3])*



There are several possible explanations for why the quiz scores were higher in Phase 3 (hydroxyzine) for both formats, vs. Phase 2 (hydromorphone). The medication studied in Phase 2 (hydromorphone) may have been more difficult to understand than the medication in Phase 3 (hydroxyzine). Second, participants were informed that they would be taking a quiz on the content of the leaflet in Phase 2, but perhaps the lived experience prompted all participants to pay closer attention in Phase 3. Participants may have anticipated the quiz in Phase 3 would ask the same questions asked in Phase 2 and were compelled to focus on that content more closely in Phase 3.

Further analyses showed that age, educational level, and English-speaking status were statistically significant. Plaza-Zamora et al. (2020) found that age was inversely correlated to medication literacy. Bosch-Lenders et al. (2016) disclosed an inverse correlation between age and the ability to identify the indication for a medication. A similar effect was observed in this study. The age group 30 to < 50 years achieved a total quiz score of 14.48 compared to the age group 65 to < 80 years, which achieved a total quiz score of 10.48 ( $p < .001$ ). Similarly, the age group 50 to < 65 years achieved a total quiz score of 13.17, also compared to the age group 65 to < 80 years, which achieved a total quiz score of 10.48 ( $p = .037$ ). Interestingly, there was no significant effect observed between the eldest old group (80 - 88 years) and any other age group.

Plaza-Zamora et al. (2020) also disclosed an inverse correlation between highest level of academic achievement and medication literacy. In this study there was only one statistically significant comparison, and that was between the groups of “High School or GED” (summed quiz score 10.85) and “Graduate degree” (summed quiz score 13.86) ( $p = .037$ ). It’s interesting that there were no other statistically significant differences among the other educational categories, including “Did not graduate High School or GED” and any level of college education.

Multiple studies have shown poorer medication literacy in IFCs with limited English proficiency (Sanderson, 2020; Semere et al., 2019; Wittenberg-Lyles et al., 2013). Those findings were consistent with the analysis in this research; native English-speaking IFC had a summed quiz score of 13.31, as compared to non-native English-speaking IFC who achieved a summed quiz score of 10.93 ( $p = .02$ ).

Mayer (2021) introduced the cognitive theory of multimedia learning (CTML), which makes assumptions of separate channels for processing visual and auditory information; the channels are capacity-limited, and one track can compensate for the other track as needed. Mayer (2021) further proposes that we can consider these two channels based on representation mode which states that a stimulus can be verbal (spoken or printed words) or nonverbal (pictures, photos, video, animation, etc.); in this fashion one channel processes verbal material, and the other processes nonverbal sounds and pictorials. Further, the sensory-modality approach explains that learners process new material through their eyes (pictures, photos, videos, etc.) or ears (spoken words or background sounds), and we can convert this new material from one modality to another. For example, an image could be converted to a sound, or a narration may be used to form a mental image, using both channels. This efficiency explains Mayer's (2021) assertion that people learn better from words and pictures, than words alone.

Infographics are seemingly an excellent example of incorporating words and pictures to enhance learning, per the CTML. Literature has shown that learners prefer an infographic to other educational objects (such as plain text) (Buljan et al., 2018; Ozdamli & Ozdal, 2018; Falk, 2016), but research on knowledge retention after studying an infographic has shown mixed outcomes with some studies finding improvement in knowledge (Alrwele, 2017; Becker et.al., 2020; Dowling et al., 2019; Ebrahimabadi et al., 2019; Egan et al. 2021; Harrison et al., 2020; Ibrahim et al., 2017) and many showing no difference or even poorer performance with the infographic (Buljan et al., 2018; Damman et al., 2018; Diamond-Smith et al., 2019; Martin et al., 2019; Ozdamli & Ozdal, 2018; Takashima et al., 2019). Studies that stated the CTML was an important element of infographic design did show an improvement in knowledge with the

infographic as compared to a non-infographic, but the authors were not forthcoming as to how the CTML was deployed in designing the infographics (Alwadei & Mohsen, 2023; Dogomeo & Aliasas, 2022; Polowsky & Steciuch, 2020). As discussed in Chapter 2, research studies on educational outcomes with use of an infographic often do not include a comparator group, do not appropriately randomize participants, or include other methodologic flaws. Also, the vast majority of research on the educational value of infographics does not mention any theoretical basis for infographic design.

There have been a few studies published in recent years claiming that the CTML is an important element of infographic design (Alwadei & Mohsen, 2023; Dogomeo & Aliasas, 2022; Polowsky & Steciuch, 2020). The study by Polowsky and Steciuch (2020) investigated student performance on a quiz following a traditional hands-on laboratory exercise on how to make cheese, as compared to a virtual laboratory exercise designed per the principles of the CTML. This is the only publication that explicitly stated how the principles of CTML were incorporated into designing the virtual laboratory exercise that incorporated dynamic infographics. In this study both groups took a pre-test on how to make cheese, and they completed a post-test after completing the laboratory exercise (traditional or virtual). The pre-post score difference was statistically significant in the virtual laboratory group ( $p < 0.0001$ ), but not the traditional laboratory group ( $p = 0.41$ ). The authors then used a cross-over design where the virtual laboratory group then completed the traditional laboratory exercise, and repeated the post-test, and the traditional laboratory exercise group then completed the virtual laboratory exercise. The group that completed the traditional laboratory exercise first, followed by the virtual laboratory exercise showed a statistically significant improvement in the second post-test ( $p = .0008$ ) but

not the other group ( $p = 0.46$ ). The author's conclusion was that a virtual multimedia learning lab exercise was more effective in learning than a traditional laboratory exercise, but there was no further discussion of why the multimedia experience resulted in significantly better learning. Also, cross-over designs have been criticized (PennState Statistics Online, 2023) because the carryover effect may confound the direct treatment effect. In the project discussed in this thesis, each of the two groups remained consistent with the form of medication information (infographic or text). Further, Mayer's (2021) principles each aim to impact one of the cognitive capacity demands (intrinsic, extraneous, or germane cognitive load). Polowsky and Steciuch (2020) made no attempt to determine the impact on cognitive capacity demands, unlike the research discussed in this thesis (research question 2). While it is reassuring that an infographic designed per the principles of the CTML resulted in significantly better knowledge retention, it is important to investigate why this occurred. Is preferring an infographic as compared to text sufficient to explain significantly better knowledge retention? A more reasonable explanation is optimization of cognitive capacities, which was investigated in Question 2.

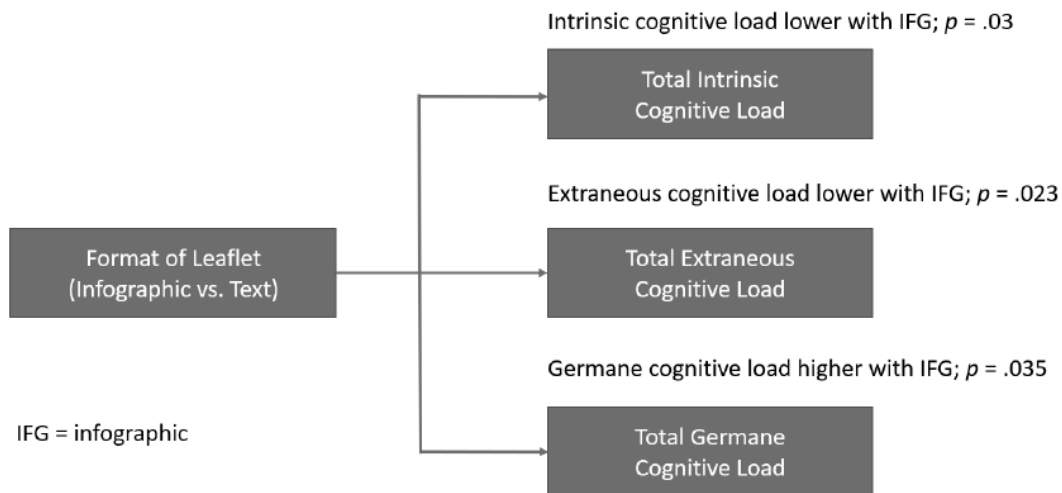
## **Research Question 2**

The second research question was "Is there a statistically significant difference in cognitive load (intrinsic, extraneous, germane), between participants viewing a medication informational leaflet prepared as an infographic versus a text passage written at the same reading level?" Recall that cognitive load refers to how much working memory is being used during a learning activity. To optimize learning, we want to reduce extraneous load, try to reduce intrinsic load, and to increase germane load.

In this research participants who viewed the infographic had a lower intrinsic cognitive load, a lower extraneous cognitive load, and a higher germane cognitive load (all statistically significant). The null hypothesis was rejected because format did make a significant difference in intrinsic, extraneous, and germane cognitive load. The results from the analysis of Question 2 are shown in Figure 5.3.

**Figure 5.3**

*Effect of Leaflet Format on Intrinsic, Extraneous, and Germane Cognitive Load*



These are important findings because reducing the inherent difficulty of a learning task (intrinsic cognitive load), and minimizing the burden not related to learning (extraneous cognitive load), permits more efficient working memory creating and integration of new information (germane cognitive load) (Debue & van de Leemput, 2014).

The study by Martin et al. (2019) had several characteristics in common with this study. Participants reviewed eight medical abstracts, half prepared as text-only, and the other half as an infographic. Outcomes included participant preference between formats, participant self-rated

cognitive load, and delayed information retention between infographic and text only article abstracts. Participants preferred the infographics ( $p = 0.01$ ) over the text abstracts. They rated the perceived mental effort to be lower with the infographic than with the text abstract ( $p = 0.01$ ). The authors found no statistically significant difference in knowledge retention at 4 weeks.

The study by Martin et al. (2019) used a two-phase within-subjects experimental model. There are advantages and disadvantages of this type of methodology (Scribbr, 2022). Advantages include requiring a smaller sample, it is statistically powerful, and removes the effects of individual differences on the outcomes. There are disadvantages as well, such as the internal validity threat that reduces the likelihood of determining a direct relationship between variables. Also, time-related effects can influence the outcomes. Most importantly, there may be a carry-over effect from one exposure (e.g., text or infographic) to the other. In the study described in this thesis, two separate groups were used to evaluate the differences between the infographic and text medication information leaflets.

To assess cognitive load, the Martin et al. study (2019) employed the 9-point Paas (1992) scale. This scale has been criticized for several reasons (Klepsch et al., 2017). First, there is only one question concerning expended mental effort; one-item scales are difficult to interpret from a psychometric perspective as the researcher cannot differentiate true variance from measurement error. Another significant drawback to the Paas (1992) scale is the inability to differentiate between intrinsic, extraneous, and germane cognitive loads. Since the goal is to reduce intrinsic and extraneous cognitive load, and increase germane cognitive load, it is impossible to determine any directional influence with the one item Paas scale (1992). In the study described in this

thesis, a 14-item cognitive load assessment instrument was used, assessing intrinsic, extraneous, and germane cognitive loads separately.

The knowledge acquisition outcome was different between the Martin et al. study (2019) and the study described in this thesis. In the former, the researchers assessed delayed information retention between the two abstract formats (and there was no statistically significant difference at 4 weeks post-intervention). In the study described here, immediate knowledge retention was assessed (which was significantly different between the two formats). The methods used in this study also allowed for more exacting differentiation between cognitive capacities (intrinsic, extraneous, germane cognitive load), and eliminates risk of a carryover effect.

### **Implications for Practice**

As evidence has shown that incorporating the CTML into the design of learning objects (such as an infographic) results in better knowledge acquisition and retention, this has enormous implications for professionals who design education such as instructional designers (Greer & Woods, 2013; Ibrahim, 2012; Sorden, 2005). It is imperative that instructional designers understand the design principles of the CTML that have a favorable impact on cognitive capacity (to reduce intrinsic and extraneous cognitive load and heighten germane load).

This research also has important implications in the education of health care providers in training, both in their personal acquisition of knowledge, as well as teaching about the use of multimedia learning objects designed to optimize cognitive capacities and learning outcomes. If health care providers use evidence-based approaches to educate IFCs, the patient and IFC will likely have a more favorable experience.

Most importantly, results from this research have important implications for clinical practice. As described in Chapter 2, IFCs of seriously ill patients assume many roles, including medication management. This research has demonstrated that providing written information as an infographic, as compared to a text medication informational leaflet, led to better knowledge retention, and had a more favorable impact on the learning process (reducing intrinsic and extraneous cognitive load, and increasing germane cognitive load). Medication information written for patient use in practice today is generally entirely text-based, and usually prepared in a very small font. For example, the U.S. Food and Drug Administration, Code of Federal Regulations Title 21 (2023), states that the body of a medication label should be printed in the font Helvetica 6 point. Yet it is recommended that Helvetica is best for type between 8 and 12 point (Urfer, 2019).

Incorporating the use of an infographic medication information leaflet designed according to the principles of the CTML, instead of text, may lead to better IFC knowledge acquisition and retention. Instituting evidence-based interventions that will enhance the IFCs understanding of the medication is an enormous patient safety advancement. Importantly, use of an infographic can be implemented by the nurse case manager in their normal interactions with the patient and/or IFC. This research did not include the added benefit of having a nurse explain the content, but it is possible that use of an infographic plus education by the nurse may enhance learning even more than demonstrated in this research.

### **Implications for Theory**

This research study was developed based on the cognitive theory of multimedia learning as promulgated by Mayer (2021). This is the first study conducted in this population, evaluating

the impact of an infographic designed per the CTML. Seven of Mayer's (2021) multimedia principles were incorporated into the design of the infographics. There are five principles that target reducing extraneous cognitive load; three were incorporated into this research. The coherence principle states that learners understand a multimedia lesson more completely when it is more concise. The theoretical rationale for this principle is that extraneous material diverts the learner's attention from the most important information, using working memory unnecessarily, and disrupting the process of organizing new information (Mayer, 2021). The signaling principle recommends adding cues to highlight the organization of essential material. This also lowers extraneous load by giving the learner an assist in drawing attention to the key elements of the learning activity (Mayer, 2021). The last principle that aims to lower extraneous cognitive load is the spatial contiguity principle, which states that words and pictures that are related should be physically near each other.

There are three principles that aim to manage essential processing (intrinsic cognitive load). Two of these three principles were incorporated into the design of the infographics. The first is the segmenting principle which prescribes user-paced segment as opposed to one continuous unit of information. This assists the learner in distinguishing one step from the next steps, facilitating understanding of the causal relationship between steps (Mayer, 2021). The second is the pre-training principle which recommends teaching the names and characteristics of main concepts of the learning activity. Pre-training reduces demands on essential processing by shifting some of the information processing to the pre-training episode (Mayer, 2021).

There are seven principles that foster generative processing (germane cognitive load). Two of these seven were incorporated into this research. The first is the personalization

principle. This seemingly small change is quite powerful, and advocates using a conversational style as opposed to a formal style in both verbal and written narratives. For example, instead of saying “call THE nurse” you would say “call YOUR nurse.” The second principle used to optimize germane cognitive load is the generative activity principle which recommends a variety of guided activities such as summarizing, mapping, drawing, imagining, self-testing, self-explaining, teaching or enacting. Generative activities foster cognitive processes as the learner selects important information and mentally organizes it and incorporates this information into prior knowledge (Mayer, 2021).

The study findings have demonstrated that adherence to Mayer’s principles (2021) in designing a multimedia learning object, such as an infographic, results in significantly better knowledge acquisition, and more favorable cognitive capacities (reduced intrinsic and extraneous load and increased germane cognitive load). Understanding the principles of the CTML, including what they are, and why they have a favorable effect on learning, is critically important for instructional designers. Adherence to the principles that pertain to the learning activity (static or dynamic) will optimize the likelihood of reducing intrinsic and extraneous cognitive load and increasing germane cognitive load.

### **Limitations of the Study**

As stated earlier, there are several limitations associated with this research. All data were collected at a single time point as a cross-sectional study; there was no follow-up or longitudinal component to this study. There are several advantages to a cross-sectional study such as the convenience of being able to collect large amounts of data in a short period of time, the ability to explain how different variables relate to each other, it’s easier to create experimental and control

groups, and the sample allows for generalizations. Disadvantages to a cross-sectional study, however, include the significant limitations to infer causality, the need for a large sample size due to potential drop out or loss to follow-up, the possibility that certain groups may not have been represented in the population, and susceptibility to non-response selection bias and information biases (Indeed, 2022).

Purposive sampling was used in this research. In purposive sampling, characteristics of the sample are defined for a purpose that is relevant to the study (Andrade, 2021). This sampling strategy results in studying the population of specific interest, and statistical significance may be more easily obtained. However, the more purposive a sample is, the external validity becomes more limited (Andrade, 2021).

Participants may have had varying levels of familiarity with one or both of the medications (hydromorphone and hydroxyzine) used to assess learning. Despite excluding individuals who were trained as or paid to work as a health care provider, some participants may have been more knowledgeable in general about pharmacology, or some participants may have had personal experience with one of the two medications, and greater familiarity. Additionally, even though this research demonstrated statistical significance, the minimum clinically important difference in quiz performance is unknown.

Research investigating the application of the principles of the CTML by Mayer (2021) and others was primarily conducted on college-age participants. Similarly, research on educational outcomes from infographic use tended to be individuals in school or training, or a population of health care providers. Findings from both of those bodies of research may not be directly applicable to this research project as the participants in this research were likely older

and probably less well educated than the aforementioned groups. Lastly, there may be researcher bias, as I was not blinded to the data when grading the knowledge assessment.

### **Recommendations for Future Research**

This study evaluated immediate knowledge retention and cognitive capacities after viewing an infographic vs. text medication information sheet. There were several methodological limitations, which could be strengthened in future research. For example, instead of a purposive sample, a probability sampling strategy could be used to assure all demographic groups are represented in both the experimental and control group. Part of purposive sampling could be querying the degree of familiarity with pharmacology in general, and specifically, the study medications.

In addition to assessing immediate knowledge retention in a cross-sectional study design, it would be interesting to make this more of a longitudinal study, also evaluating knowledge retention at a point later in time, such as 4 weeks post-intervention. Taking it one step further would be assessment of knowledge transfer after viewing an infographic vs. text medication information leaflet. In other words, presenting the IFC with a hypothetical situation and having them make a decision about patient care based on what they learned from the medication information leaflet. This type of research may also help identify the minimal clinically important difference in quiz performance that results in improved patient care. It would also be interesting to evaluate the use of an infographic vs. a text medication information leaflet combined with the nurse's explanation about the medication, pointing out the important points as s/he provides verbal education.

## Appendix A - Definition of Terms

A clear understanding of terms in the study title and research questions is necessary to fully understand the scope of the study.

**Cognitive load** – a “multidimensional construct representing the load that performing a particular task imposes on the learner’s cognitive system” (Paas et al., 2008, p. 13)

***Intrinsic cognitive load*** – task complexity (van Merriënboer & Sweller, 2010)

***Extraneous load*** – instructional features that are not beneficial to learning (van Merriënboer & Sweller, 2010)

***Germane load*** – the mental effort that leads to understanding the new information (van Merriënboer & Sweller, 2010)

**Infographic** – an information graphic, designed to be an engaging method to convey key messages (Barlow, Webb, & Barlow, 2020a)

**Informal caregiver (IFC)** - defined as “a relative, spouse, partner, or friend who provides care and support to someone at home without pay” (Campione & Zebrak, 2020).

**Knowledge retention** – garnering knowledge that can be used later (Agarwal & Islam, 2015). Immediate knowledge retention refers to accessing acquired knowledge immediately after a learning event.

**Medication information delivery format** – infographic vs. text.

**Medication knowledge in hospice care** – refers to information pertaining to a medication’s purpose, when and how to administer the medication, how to monitor the patient for medication-related side effects, and actions to take if a side effect occurs (Lau et al., 2009; Wilson et al., 2018).

## Appendix B - Hydromorphone Infographic Leaflet

### THE BASICS OF HydroMORphone (Dilaudid)



#### HOW WILL THIS MEDICINE HELP ME?

-  It reduces pain
-  With less pain, you can do more activities.
-  Makes you feel less short of breath.

#### HOW AND WHEN DO I TAKE THE MEDICINE?

-  Take it by mouth
-  Your nurse will tell you how many times per day you should take it.



#### WHEN WILL IT WORK?

-  It starts working in about 30 minutes

#### COMMON SIDE EFFECTS?



-  **CONSTIPATION**  
Your nurse will tell you how to treat this.
-  **SLEEPINESS AND CONFUSION**
  - ✓ This should get better with time.
  - ✓ Be careful about driving or using things like a lawn mower or snow blower.
  - ✓ Don't drink alcohol while taking this medicine.

#### SERIOUS SIDE EFFECTS? CALL YOUR NURSE




- If it is hard to wake up or stay awake, call your nurse.
- If you have changes in your breathing (such as slower than normal), call your nurse.
- If you have painful stomach cramps or no bowel movements, call your nurse.




Disclaimer: This infographic is not intended to be a substitute for professional medical advice, diagnosis, or treatment. After reading content like this infographic, you are encouraged to review the information carefully with your professional healthcare provider.

## Appendix C - Hydroxyzine Infographic Leaflet


### THE BASICS OF **Hydroxyzine** (Vistaril, Atarax)





#### HOW WILL THIS MEDICINE HELP ME?

-  Reduces itching and skin rash
-  Reduces feelings of anxiety or restlessness
-  Helps you fall and stay asleep



#### HOW AND WHEN DO I TAKE THE MEDICINE?

 Take it by mouth one to four times a day

#### WHEN WILL IT WORK?




-  In about one hour, you will feel less itching, anxiety, and restlessness
-  In about one hour, it will help you fall and stay asleep
-  It may take a day or longer before your rash starts getting better

#### COMMON SIDE EFFECTS?

- **SLEEPINESS AND CONFUSION**
  - This will likely get better with time.
  - Be careful about driving or using things like a lawn mower, snow blower, etc.
  - Don't drink alcohol while you are taking this medicine.
- **DRY MOUTH**

Sucking on ice chips will help our mouth feel less dry.

#### SERIOUS SIDE EFFECTS? CALL YOUR NURSE

- 
-  If it is hard to wake up or stay awake, call the nurse.
-  If you have changes in breathing (such as slower than normal), call the nurse.

Disclaimer: This is not intended to be a substitute for medical advice, diagnosis, or treatment. After reading this, you are encouraged to review the information carefully with your professional healthcare provider.

## **Appendix D – Verbal Consent and Script**

**Script read by Dr. McPherson for all encounters with students and participants.**

### **Explanation of Study and Consent**

You are being asked to participate in a research project that aims to evaluate the knowledge gained after reviewing a medication information leaflet, and the “cognitive load” (how hard someone has to work to understand new information). You are being asked to participate in this research because you either serve or have served as a caregiver to a patient receiving hospice or palliative care or is/was living with a serious illness. We will be collecting some basic demographic information, showing you a medication informational leaflet, asking you to take a brief quiz about the medication, and to share your opinion on how much work it took to learn the information. You will complete these steps for two medications. The entire process should not exceed 30 minutes.

Your participation in this study is entirely voluntary. There will be no penalty or consequence if you choose not to participate in this project, and you can drop out at any time with no repercussions. You can choose not to answer a question. All information collected will only be reported in aggregate. Your name or any identifying information will never be asked for or recorded.

Risks include invasion of your privacy, the potential for a breach of confidentiality, psychological distress, or social embarrassment, although the risk is quite low. The benefit of this research is to help hospices better prepare caregivers for the task of medication management in the future, and potentially better pain and symptom control for the patient due to this better

education. If you have any questions about this project, please contact the principal investigator, Dr. Mary Lynn McPherson at 410-706-3682, or [mmcphers@rx.umaryland.edu](mailto:mmcphers@rx.umaryland.edu).

**Dr. McPherson to read the following script on the video conference, instructing the student and participant step by step.**

<b>Student Action</b>	<b>Script to be read</b>
Hand participant page 2 – Demographic Information	Please take the page titled “Demographic Information” and complete it. Once you are done, please return the sheet to the student.
Take back sheet on Demographic Information (page 2) and hand participant Pre-training Infographic (page 3)	In this project you will learn about two medications that have a similar-sounding name. The first medication is hydromorphone, also known as Dilaudid. The second medication is called hydroxyzine, also known as Vistaril or Atarax. When you’re done with this sheet, please hand it back to the student.
Take back Pre-training Infographic (page 3) and <i>after script is read</i> , hand participant hydromorphone leaflet (page 4)	You will have 90 seconds to read, review, and study the medication information leaflet on hydromorphone. I will let you know when the 90 seconds are up. After you review this leaflet, you will be taking a quiz about the content of this leaflet.  90 seconds are up, please hand the information leaflet back to the student.
Take back the hydromorphone leaflet (page 4). Hand participant hydromorphone quiz <i>after script is read</i> (page 5)	You have 2 minutes to complete the quiz on hydromorphone. You may not refer back to the medication information leaflet or ask anyone for assistance. I will let you know when the two minutes are up.  Two minutes are up, please hand the quiz back to the student.
Take back the hydromorphone quiz (page 5). Hand participant Part I of the Cognitive Load Assessment (page 6); participant may view this page while script is being read.	Next you will be completing a survey that asks you rate how easy or difficult it was to understand the information on the hydromorphone leaflet.  You see a series of statements numbered 1-14. Circle the number, 0-10, which best reflects your opinion. For example, the first statement is “the medication information covered in the activity was very complex.” The options range from 0, which is not at all the case (meaning you disagree strongly with that statement), up to 10 (completely the case), meaning you strongly agree with that statement.  For all the statements, 0 will always be “not at all the case”, meaning you strongly disagree, and 10 will be “completely the

	<p>case”, or you strongly agree. And of course, numbers 1-9 are between those two ends. Circle the number that best reflects your opinion.</p> <p>Let us go item by item. [Read items 1-14, and remind participant of what 0 equals, and what 10 equals.]</p> <p>When you are done, hand page 6 back to the student.</p>
<p>Take back Cognitive Load Assessment Part 1 (page 6). Hand participant Part 2 of the Cognitive Load Assessment (page 7); participant may view this page while script is being read.</p>	<p>This is the second part of the survey.</p> <p>There are three statements with the same possible responses, 0-10.</p> <p>[Read items 1-3, and remind participant of what 0 equals, and what 10 equals.]</p> <p>When you are done, hand page 7 back to the student.</p>
<p>Take back Cognitive Load Survey Part 2 (page 7) and <b>after script is read</b>, hand participant hydroxyzine leaflet (page 8)</p>	<p>We’re going to repeat the same process with the second medication. You will have 90 seconds to read, review, and study the medication information leaflet on hydroxyzine. I will let you know when the 90 seconds are up. After you review this leaflet, you will be taking a quiz about the content of this leaflet.</p> <p>90 seconds are up, please hand the information leaflet back to the student.</p>
<p>Take back the hydroxyzine leaflet (page 8). Hand participant hydroxyzine quiz <b>after script is read</b> (page 9)</p>	<p>You have 2 minutes to complete the quiz on hydroxyzine. You may not refer back to the medication information leaflet or ask anyone for assistance. I will let you know when the two minutes are up.</p> <p>Two minutes are up, please hand the quiz back to the student.</p>
<p>Take back the hydroxyzine quiz (page 9). Hand participant Part I of the Cognitive Load Assessment (page 10); participant may view this page while script is being read.</p>	<p>Next you will be completing a survey that lets you rate how easy or difficult it was to understand the information on the hydroxyzine leaflet.</p> <p>You see a series of statements numbered 1-14. Circle the number, 0-10, which best reflects your opinion. For example, the first statement is “the medication information covered in the activity was very complex.” The options range from 0, which is not at all the case (meaning you disagree strongly with that statement), up to 10 (completely the case), meaning you strongly agree with that statement.</p>

	<p>For all the statements, 0 will always be not at all the case, meaning you strongly disagree, and 10 will be completely the case, or you strongly agree. And of course, numbers 1-9 are between those two ends. Circle the number that best reflects your opinion.</p> <p>Let us go item by item. [Read items 1-14, and remind participant of what 0 equals, and what 10 equals.]</p> <p>When you are done, hand page 10 back to the student.</p>
<p>Take back Cognitive Load Assessment Part 1 (page 10). Hand participant Part 2 of the Cognitive Load Assessment (page 11); participant may view this page while script is being read.</p>	<p>This is the second part of the survey.</p> <p>There are three statements with the same possible responses, 0-10.</p> <p>[Read items 1-3, and remind participant of what 0 equals, and what 10 equals.]</p> <p>When you are done, hand page 11 back to the student.</p>
<p>Take back Cognitive Load Assessment Part 2 (page 11)</p>	<p>This concludes our project. I would like to thank you sincerely for your time. Your efforts will help health care providers provide the best education possible to patients about their medications.</p>
<p>PLEASE scan or take a photo of all pages so you can complete your assignment. Reassemble the two packets and mail them to Dr. McPherson. By scanning or photographing, if your packet gets lost in the mail, you can forward the electronic version to Dr. McPherson. Thank you!</p>	

## Appendix E - Demographic information

- What is your age?
  - 18 to < 30 years
  - 30 to < 50 years
  - 50 to < 65 years
  - 65 to < 80 years
  - $\geq$  80 years
  
- What is your gender?
  - Male
  - Female
  - Prefer not to disclose
  
- What is your highest level of education?
  - Did not graduate high school or GED
  - High school or GED
  - Some college, no degree
  - Associate degree
  - Bachelor's degree
  - Graduate degree
  
- Which of the following ethnic groups do you self-identify?
  - American Indian or Alaska Native
  - Asian
  - Black or African American
  - Native Hawaiian or other Pacific Islander
  - White
  - Prefer not to disclose
  
- Are you a native English speaker, or a non-native English speaker (in other words, you speak English as a second language)?
  - Native English speaker
  - Non-native English speaker (speaks English as a second language)

Appendix F – Pre-training Infographic



## **Appendix G - The Basics of Hydromorphone (Dilaudid)**

The name of this medicine is hydromorphone (Dilaudid). It is used to reduce pain. With less pain, you can do more activities. It can also make you feel less short of breath. This medicine is taken by mouth, and your nurse will tell you how many times per day you should take it. This medicine starts working in about 30 minutes. The medicine commonly causes constipation. Your nurse will tell you how to treat this. The medicine can also cause sleepiness and confusion. This should get better with time. Be careful about driving or using things like a lawn mower or snow blower. Don't drink alcohol while taking this medicine. If it is hard to wake up or stay awake, call the hospice nurse. If you have changes in your breathing (such as slower than normal), call the nurse. If you have painful stomach cramps or no bowel movements, call the nurse.

## **Appendix H - The Basics of Hydroxyzine (Vistaril, Atarax)**

The name of this medicine is hydroxyzine (Vistaril, Atarax). It is used to reduce itching and skin rash. It also reduces feelings of anxiety or restlessness. It can help you fall asleep and stay asleep. This medicine is taken by mouth, and you will take it between one and four times a day. In about one hour, you will feel less itching, anxiety, and restlessness. In about one hour, it will help you fall and stay asleep. It may take a day or longer before your rash starts getting better. This medicine may cause your mouth to feel dry. Sucking on ice chips will help your mouth feel less dry. The medicine may make you sleepy or confused. This will likely get better with time. Be careful about driving or using things like a lawn mower or snow blower. Don't drink alcohol while taking this medicine. If you have a hard time waking up or staying awake, call the nurse. If you have changes in your breathing (such as slower than normal), call the nurse.

## **Appendix I - Hydromorphone (Dilaudid) Quiz**

**Knowledge Survey - please respond based on the information presented in the leaflet.**

1. How will hydromorphone (Dilaudid) help you?
2. When do you take the medicine?
3. When will hydromorphone (Dilaudid) work?
4. What common side effects may occur with this medicine?
5. What serious side effects may occur with hydromorphone (Dilaudid), for which the hospice nurse should be called?

## **Appendix J - Hydroxyzine (Vistaril, Atarax) Quiz**

**Knowledge Survey - please respond based on the information presented in the leaflet.**

1. How will hydroxyzine (Vistaril, Atarax) help you?
2. When do you take the medicine?
3. When will the hydroxyzine (Vistaril, Atarax) work for anxiety and restlessness?
4. When will the hydroxyzine (Vistaril, Atarax) work for rash?
5. What common side effects may occur with this medicine?
6. What serious side effects may occur with hydroxyzine (Vistaril, Atarax), for which the hospice nurse should be called?

## Appendix K - Cognitive Load Assessment – Part 1

**Please respond to each of the questions on the following scale:  
0 meaning *not at all the case* and 10 meaning *completely the case***

Q#	CL *	Statement	0 = <b>not at all</b> the case 10 = <b>completely</b> the case										
			0	1	2	3	4	5	6	7	8	9	10
1	IL	The medication information covered in the activity was very complex.	0	1	2	3	4	5	6	7	8	9	10
2	IL	The instructions and/or explanations about the activity were very unclear.	0	1	2	3	4	5	6	7	8	9	10
3	EL	Other noises and distractions during the activity made it hard to learn.	0	1	2	3	4	5	6	7	8	9	10
4	GL	The activity really enhanced my understanding of the medication covered.	0	1	2	3	4	5	6	7	8	9	10
5	IL	The activity covered medication information that I thought was very complex.	0	1	2	3	4	5	6	7	8	9	10
6	EL	Noises in the environment made it difficult to focus on the learning content.	0	1	2	3	4	5	6	7	8	9	10
7	GL	The activity really enhanced my knowledge and understanding of how and when to take the medication.	0	1	2	3	4	5	6	7	8	9	10
8	EL	The instructions and/or explanations were, in terms of learning, very ineffective.	0	1	2	3	4	5	6	7	8	9	10
9	GL	The activity really enhanced my knowledge and understanding of the medication's side effects.	0	1	2	3	4	5	6	7	8	9	10
10	IL	The activity covered facts and information about a medication that I thought was very complex.	0	1	2	3	4	5	6	7	8	9	10
11	EL	Distractions in the environment made learning ineffective.	0	1	2	3	4	5	6	7	8	9	10
12	EL	The instructions and/or explanations were full of unclear language.	0	1	2	3	4	5	6	7	8	9	10
13	GL	The activity really enhanced my understanding of facts and information about the medication.	0	1	2	3	4	5	6	7	8	9	10
14	EL	Unrelated events occurring in the environment made it difficult to learn.	0	1	2	3	4	5	6	7	8	9	10

\* CL (cognitive load) – IL – intrinsic load; EL – extraneous load; GL – germane load

## Appendix L - Cognitive Load Assessment – Part 2

After reading the medication information leaflet you just completed, to what extent was your mind occupied by the following three activities:

Please respond to each of the questions on the following scale:  
**0** meaning *not at all the case* and **10** meaning *completely the case*

Q#	Statement	0 = <b>not at all</b> the case 10 = <b>completely</b> the case										
		0	1	2	3	4	5	6	7	8	9	10
1	The overall difficulty of understanding the medication information.											
2	Thoughts or distractions not essential to learning about the medication.											
3	My efforts to understand and learn about the medication.											

## Appendix M – Andersen/Sewell Cognitive Load Statements

### Comparison of Andersen and Makransky (2021) and Sewell et al., (2016) original cognitive load statements, and adaptations for proposed research.

#### Intrinsic Load:

Andersen and Makransky (2021)	Proposed Research
<ul style="list-style-type: none"> <li>• The topics covered in the activity were very complex</li> <li>• The activity covered theories that I perceived as very complex</li> <li>• The activity covered concepts and definitions that I perceived as very complex</li> </ul>	<ul style="list-style-type: none"> <li>• The medication information covered in the activity was very complex</li> <li>• The activity covered medication information that I thought was very complex</li> <li>• The activity covered facts and information about medications that I thought was very complex</li> </ul>

#### Extraneous Load:

Andersen and Makransky (2021)	Proposed Research
<ul style="list-style-type: none"> <li>• The instructions and/or explanations during the activity were very unclear</li> <li>• The instructions and/or explanations were, in terms of learning, were very ineffective</li> <li>• The instructions and/or explanations were full of unclear language</li> <li><del>• Other students talking in the classroom made it difficult to focus on the learning content*</del></li> <li><del>• Students talking to me during the activity made learning ineffective</del></li> <li>• Other noises and distractions during the activity made it hard to learn</li> <li>• Noises in the environment made it difficult to focus on the learning content</li> <li>• Distractions in the environment made learning ineffective</li> <li>• Unrelated events occurring in the environment made it difficult to focus</li> </ul>	<ul style="list-style-type: none"> <li>• The instructions and/or explanation about the activity were very unclear</li> <li>• The instructions, and/or explanations were, in terms of learning, very ineffective.</li> <li>• The instructions and/or explanations were full of unclear language.</li> <li>• Other noises and distractions during the activity made it hard to learn</li> <li>• Noises in the environment made it difficult to focus on the learning content</li> <li>• Distractions in the environment made learning ineffective</li> <li>• Unrelated events occurring in the environment made it difficult to focus</li> </ul>

<ul style="list-style-type: none"> <li>● <del>My activities on my phone/computer made it difficult to focus on the learning content</del></li> <li>● <del>Messages and notifications from my phone/ computer made learning unclear</del></li> <li>● <del>Others' phone/computer use distracted me, making it hard to learn</del></li> <li>● <del>Low quality audio made the instructions hard to follow</del></li> <li>● <del>Technical issues made learning ineffective</del></li> <li>● Problems with technology made it difficult to focus</li> </ul>	
--	--

**Germane Load:**

<b>Andersen and Makransky (2021)</b>	<b>Proposed Research</b>
<ul style="list-style-type: none"> <li>● The activity really enhanced my understanding of the topic covered</li> <li>● The activity really enhanced my knowledge and understanding of cognitive load</li> <li>● The activity really enhanced my understanding of the theories covered</li> <li>● The activity really enhanced my understanding of concepts and definitions</li> </ul>	<ul style="list-style-type: none"> <li>● The activity really enhanced my understanding of the medication covered</li> <li>● The activity really enhanced my knowledge and understanding of how and when to take the medication</li> <li>● The activity really enhanced my knowledge and understanding of the medication's side effects</li> <li>● The activity really enhanced my understanding of facts and information about the medication</li> </ul>

**Global Rating Scale:**

<b>Sewell et al., (2016)</b>	<b>Proposed Research</b>
<ul style="list-style-type: none"> <li>● IL – The overall difficulty of this colonoscopy</li> <li>● EL – Thoughts or distractions not essential to performing or learning colonoscopy</li> <li>● GL – My efforts to understand and learn colonoscopy technique</li> </ul>	<ul style="list-style-type: none"> <li>● IL – The overall difficulty of understanding the medication information</li> <li>● EL – Thoughts or distractions not essential to learning about the medication</li> <li>● GL – My efforts to understand and learn about the medication</li> </ul>

\* - stricken items not used in proposed research

## Appendix N – IRB Approval and Script for Research



University of Maryland, Baltimore  
Institutional Review Board (IRB)  
Phone: (410) 706-5037  
Email: [hrpo@umaryland.edu](mailto:hrpo@umaryland.edu)

### EXEMPT DETERMINATION

**OF NOTE: The Principal Investigator should review the University of Maryland Baltimore criteria for performing research during the current COVID-19 pandemic emergency. Understand that IRB approval of this research does not suggest that performance of this research under current guidelines is allowed. Failure to comply with the UMB President's directives would be considered non-compliance. The UMB Research directives can be found at <https://www.umaryland.edu/coronavirus/>. If you need clarification or guidance please call the Human Research Protections Office at 410-706-5037.**

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Date: December 16, 2022

To: Christina Cestone  
RE: HM-HP-00103372-1  
Protocol Version and ID #: N/A  
Type of Submission: Modification  
Type of IRB Review: Exempt

**Determination Date: 12/16/2022**

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This is to certify that University of Maryland, Baltimore (UMB) Institutional Review Board (IRB) has reviewed the above referenced modification request for the protocol entitled, "Med Info Delivery Format McPherson PhD."

Your protocol continues to be exempt under 45 CFR.46.104(d) from IRB review.

In conducting this research you are required to follow the requirements listed in the INVESTIGATOR MANUAL. Investigators are reminded that the IRB must be notified of any changes in the study. Research activity involving veterans or the Baltimore VA Maryland Healthcare System (BVAMHCS) as a site, must also be approved by the BVAMHCS Research and Development Committee prior to initiation. Contact the VA Research Office at 410-605-7131 for assistance.

In conducting this research you are required to follow the requirements listed in the INVESTIGATOR MANUAL. Investigators are reminded that the IRB must be notified of any changes in the study. Research activity in which the VA Maryland Healthcare System (VAMHCS) is a recruitment site or in which VA resources (i.e., space, equipment, personnel, funding, data) are otherwise involved, must also be approved by the VAMHCS Research and Development Committee prior to initiation at the VAMHCS. Contact the VA Research Office at 410-605-7000 ext. 6568 for assistance.

The UMB IRB is organized and operated according to guidelines of the International Council on Harmonization, the United States Office for Human Research Protections and the United States Code of Federal Regulations and operates under Federal Wide Assurance No. FWA00007145.

1 of 2

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If you have any questions about this review or questions, concerns, and/or suggestions regarding the Human Research Protection Program (HRPP), please do not hesitate to contact the Human Research Protections Office (HRPO) at (410) 706-5037 or [HRPO@umaryland.edu](mailto:HRPO@umaryland.edu).

## Appendix O - Hydromorphone (Dilaudid) Quiz Key

**Knowledge Survey - please respond based on the information presented in the leaflet.**

1. How will hydromorphone (Dilaudid) help you? (3 points)

*It reduces pain*

*Can do more activities*

*Less shortness of breath*

2. When do you take the medicine? (1 point)

*When the nurse tells you to take it*

3. When will hydromorphone (Dilaudid) work? (1 point)

*In about 30 minutes*

4. What common side effects may occur with this medicine? (2 points)

*Constipation*

*Sleepiness and/or confusion*

5. What serious side effects may occur with hydromorphone (Dilaudid), for which the hospice nurse should be called? (3 points)

*Hard to wake up OR stay awake*

*Changes in breathing*

*Stomach cramp OR constipation*

## Appendix P - Hydroxyzine (Vistaril, Atarax) Quiz Key

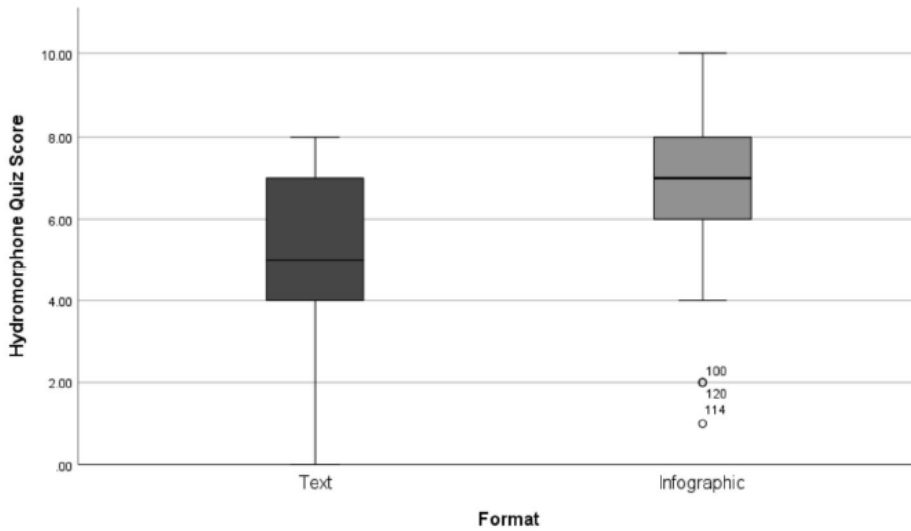
**Knowledge Survey - please respond based on the information presented in the leaflet.**

1. How will hydroxyzine (Vistaril, Atarax) help you? (3 points)  
*Reduces itching OR skin rash*  
*Reduces anxiety OR restlessness*  
*Helps you fall asleep OR stay asleep*
2. When do you take the medicine? (1 point)  
*One to four times a day*
3. When will the hydroxyzine (Vistaril, Atarax) work for anxiety and restlessness? (1 point)  
*About one hour*
4. When will the hydroxyzine (Vistaril, Atarax) work for rash? (1 point)  
*A day or longer*
5. What common side effects may occur with this medicine? (2 points)  
*Sleepiness OR confusion*  
*Dry mouth*
6. What serious side effects may occur with hydroxyzine (Vistaril, Atarax), for which the hospice nurse should be called? (2 points)  
*Hard to wake up OR stay awake*  
*Changes in breathing*

## Appendix Q – Supporting Figures

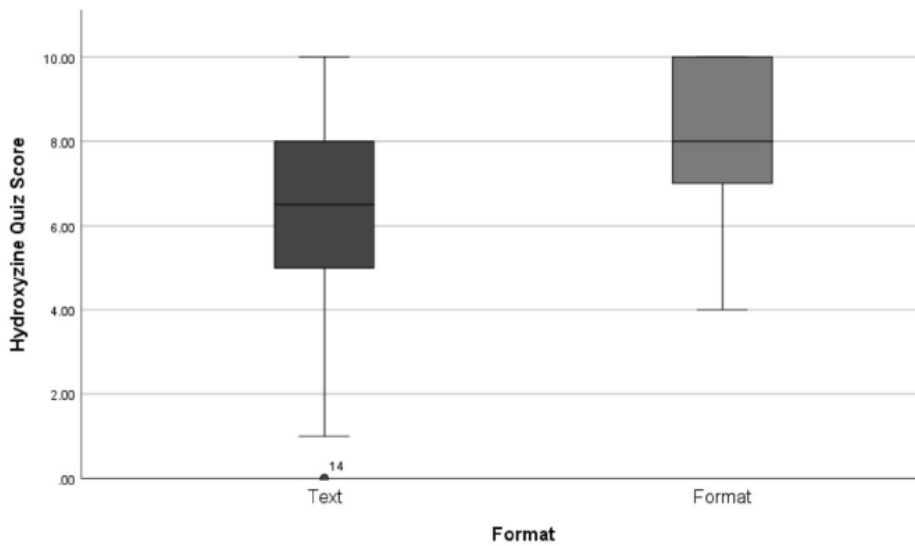
**Figure Q.1**

*Hydromorphone Quiz Score by Format (Text vs. Infographic)*



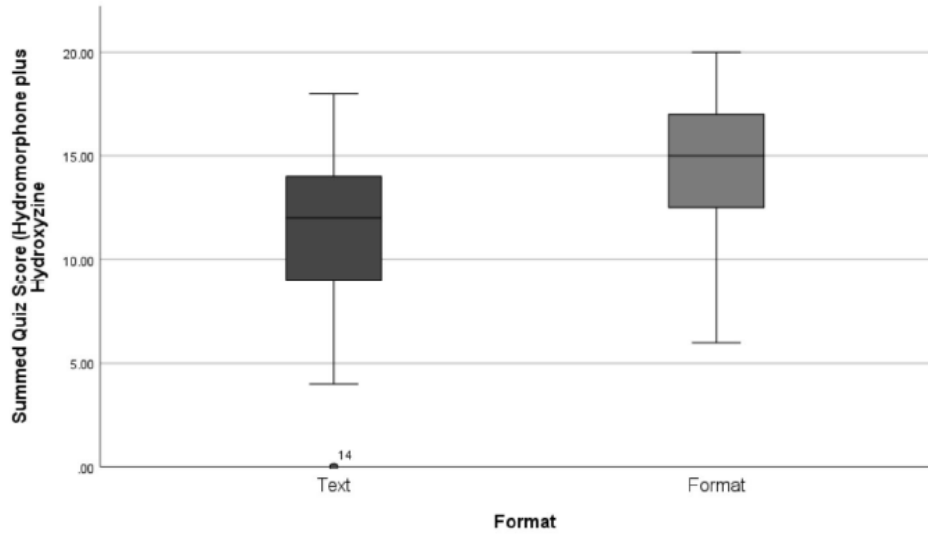
**Figure Q.2**

*Hydroxyzine Quiz Score by Format (Text vs. Infographic)*



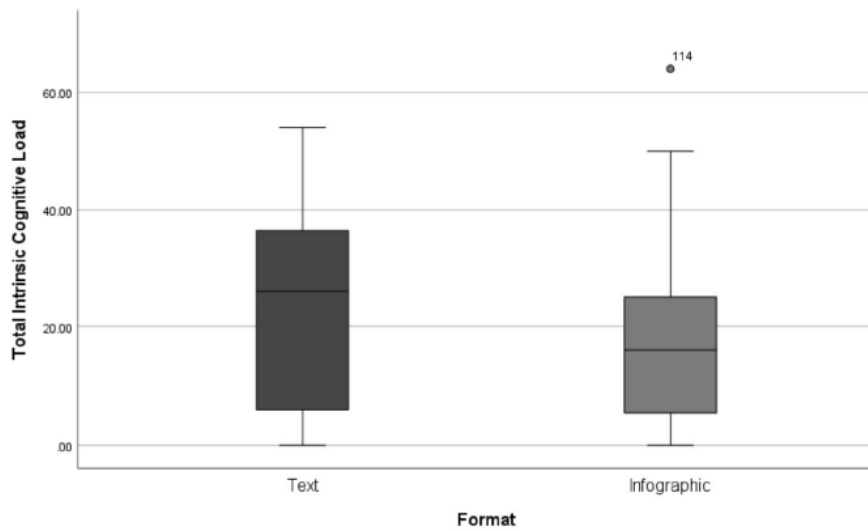
**Figure Q.3**

*Summed Quiz Score (Hydromorphone plus Hydroxyzine) by Format (Text vs. Infographic)*



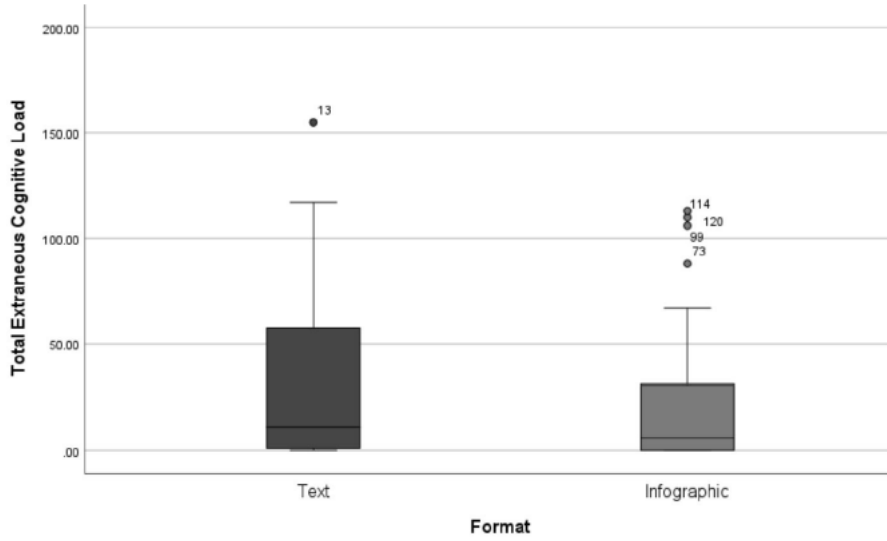
**Figure Q.4**

*Total Intrinsic Cognitive Load by Format (Text vs. Infographic)*



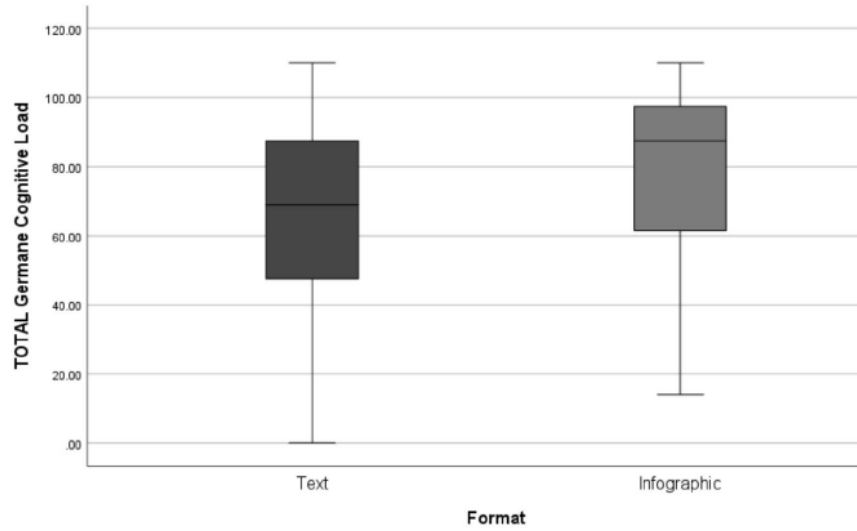
**Figure Q.5**

*Total Extraneous Cognitive Load by Format (Text vs. Infographic)*



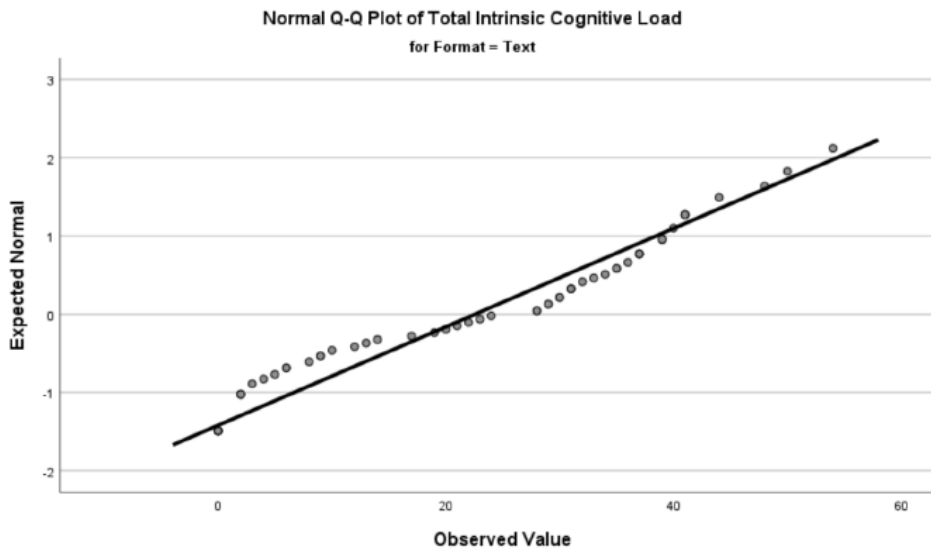
**Figure Q.6**

*Total Germane Cognitive Load by Format (Text vs. Infographic)*



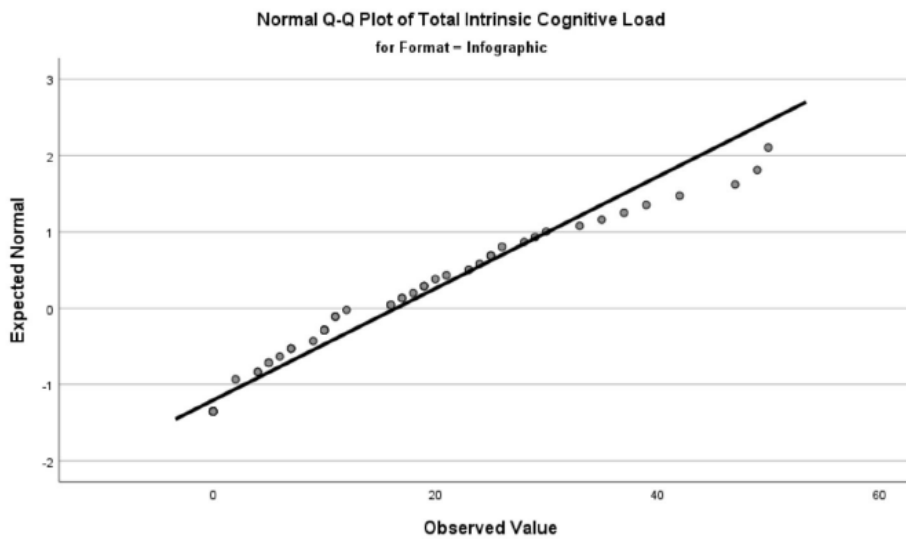
**Figure Q.7**

*Total Intrinsic Cognitive Load by Format (Text)*



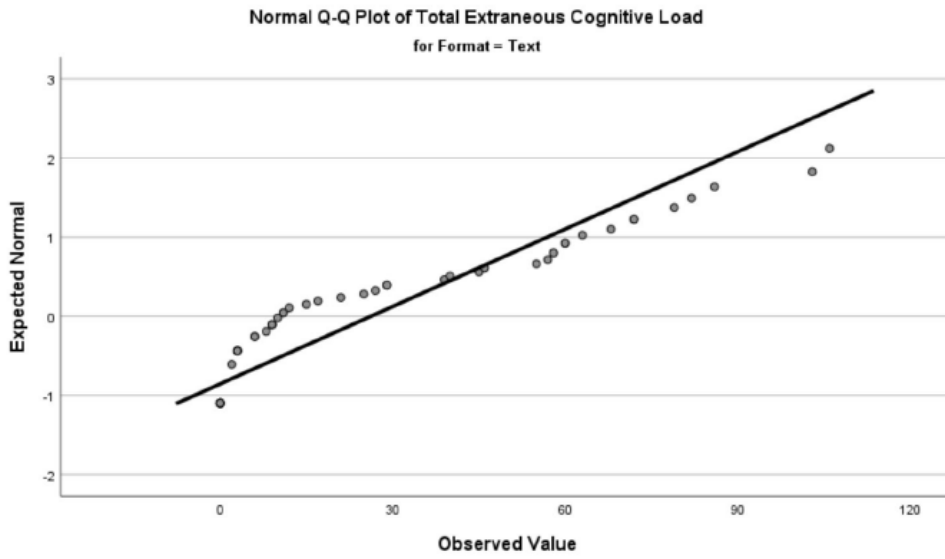
**Figure Q.8**

*Total Intrinsic Cognitive Load by Format (Infographic)*



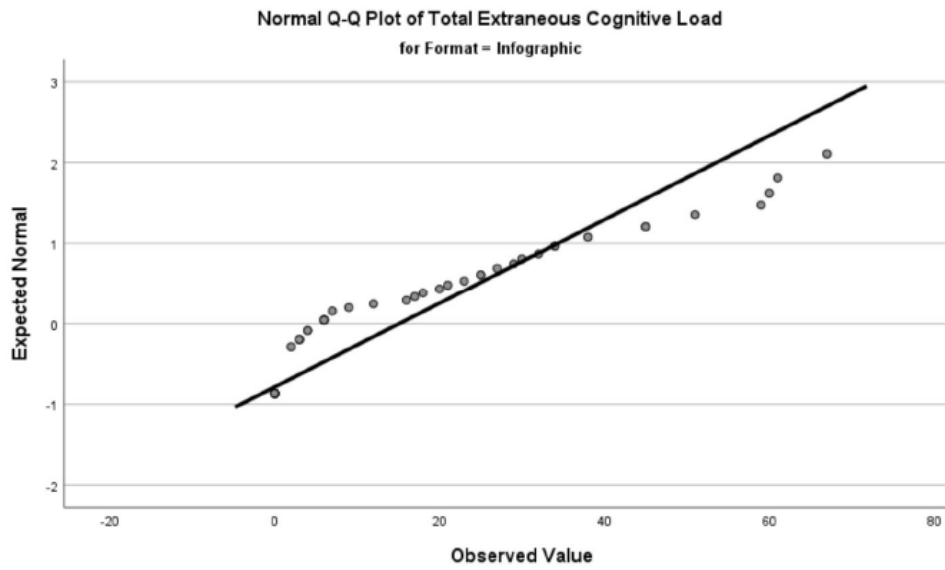
**Figure Q.9**

*Total Extraneous Cognitive Load by Format (Text)*



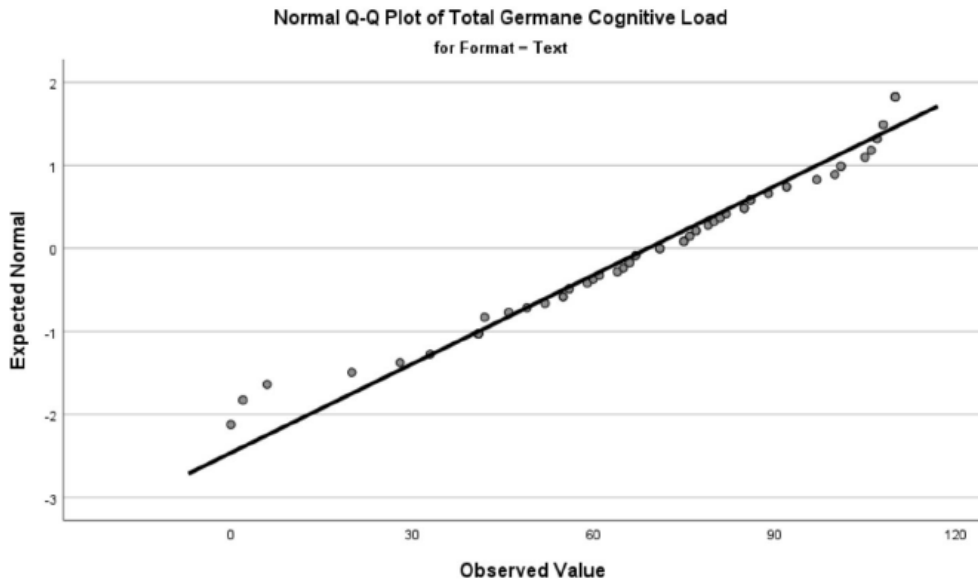
**Figure Q.10**

*Total Extraneous Cognitive Load by Format (Infographic)*



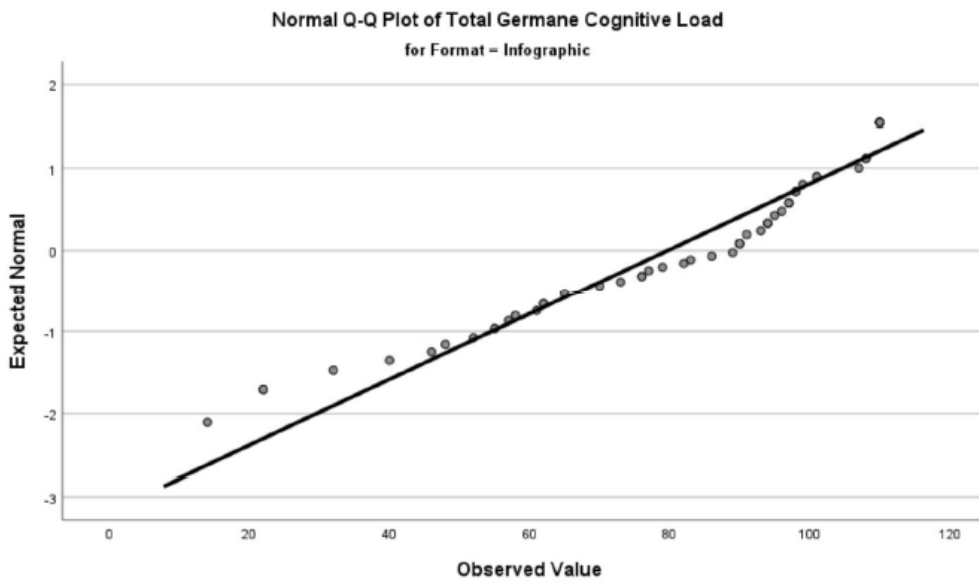
**Figure Q.11**

*Total Germane Cognitive Load by Format (Text)*



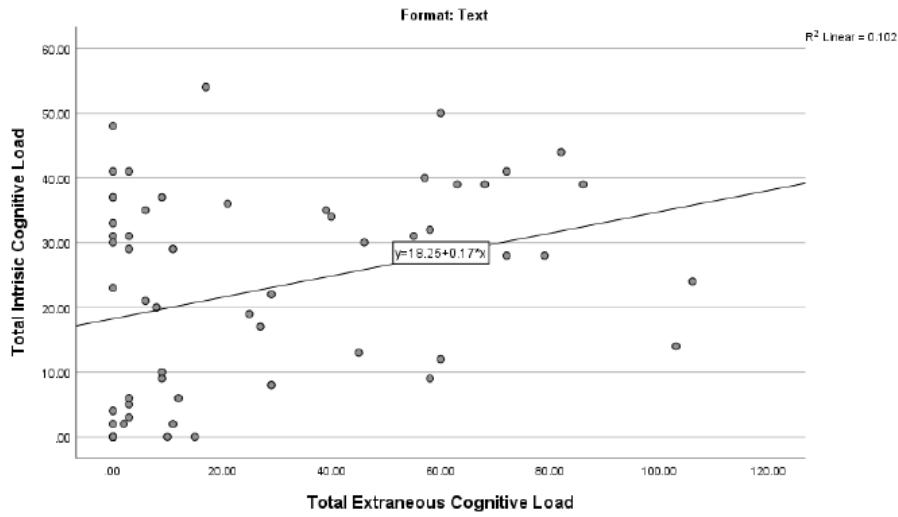
**Figure Q.12**

*Total Germane Cognitive Load by Format (Infographic)*



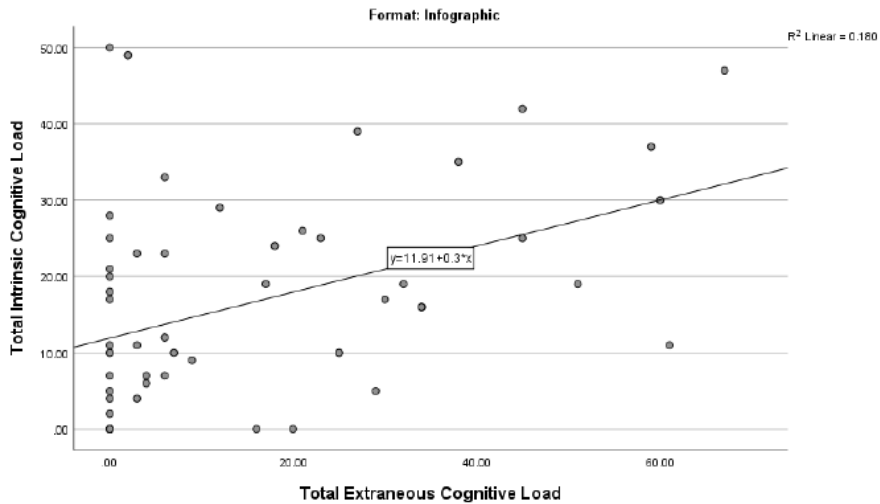
**Figure Q.13**

*Scatterplot Relationship Between Total Intrinsic Cognitive Load and Total Extraneous Cognitive Load for Text Format*



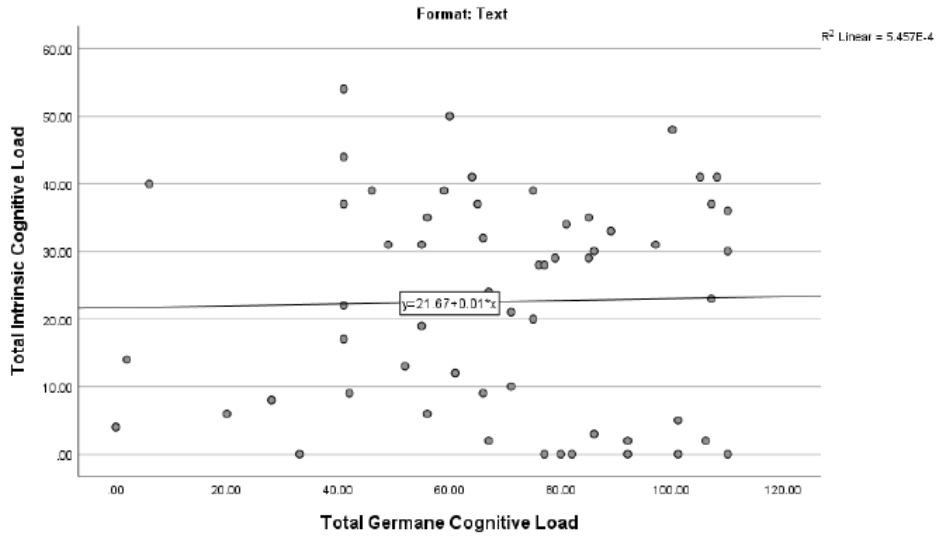
**Figure Q.14**

*Scatterplot Relationship Between Total Intrinsic Cognitive Load and Total Extraneous Cognitive Load for Infographic Format*



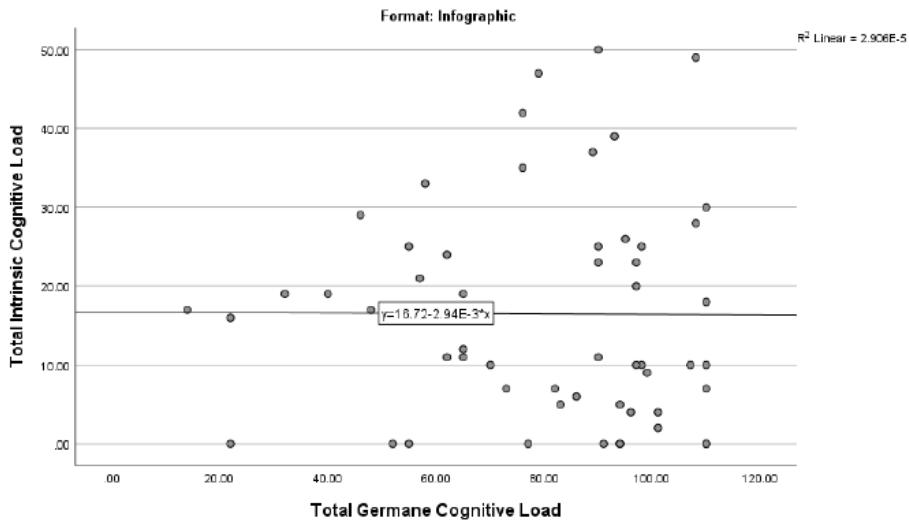
**Figure Q.15**

*Scatterplot Relationship Between Total Intrinsic Cognitive Load and Total Germane Cognitive Load for Text Format*



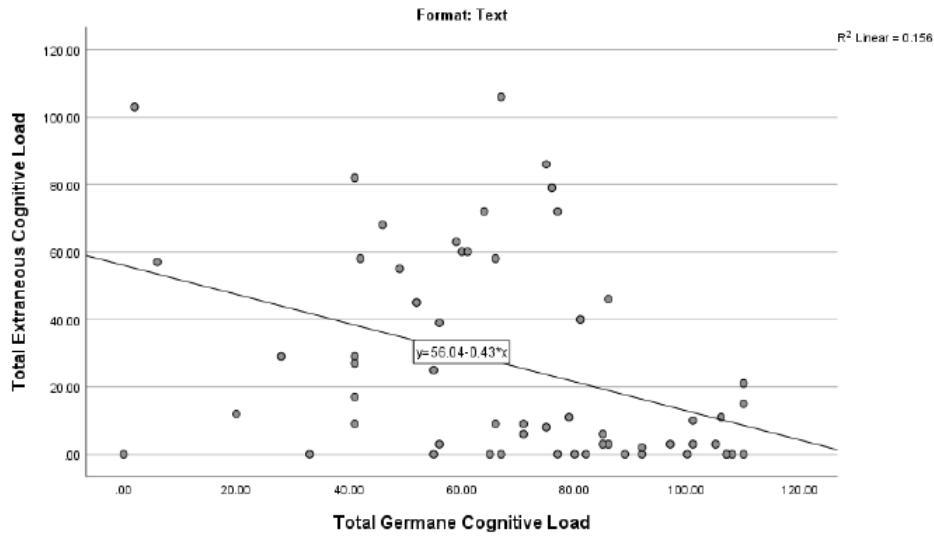
**Figure Q.16**

*Scatterplot Relationship Between Total Intrinsic Cognitive Load and Total Germane Cognitive Load for Infographic Format*



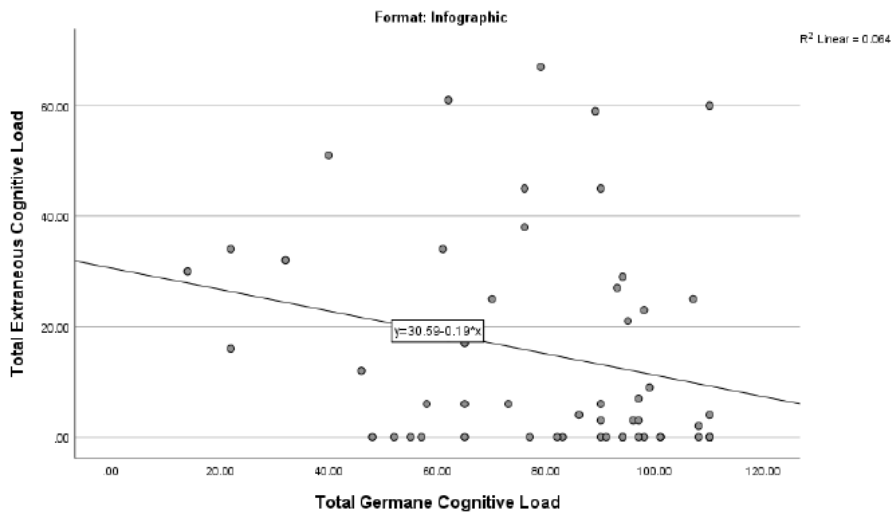
**Figure Q.17**

*Scatterplot Relationship Between Total Extraneous Cognitive Load and Total Germane Cognitive Load for Text Format*



**Figure Q.18**

*Scatterplot Relationship Between Total Extraneous Cognitive Load and Total Germane Cognitive Load for Infographic Format*



## Appendix R – Supporting Tables

**Table R.1**

*Descriptive Statistics for Hydromorphone (Phase 2) Quiz Scores by Format*

Variable	Format		<i>N</i>	Minimum	Maximum	<i>M</i>	<i>SD</i>
Quiz Score	Infographic (Group A)	Quiz scores	60	1	10	6.7	1.9
		Valid <i>N</i> (listwise)	60				
	Text (Group B)	Quiz scores	60	0	8	5.4	1.7
		Valid <i>N</i> (listwise)	60				

**Table R.2**

*Descriptive Statistics for Hydroxyzine (Phase 3) Quiz Scores by Format*

Variable	Format		<i>N</i>	Minimum	Maximum	<i>M</i>	<i>SD</i>
Quiz Score	Infographic (Group A)	Quiz scores	60	4	10	7.9	1.8
		Valid <i>N</i> (listwise)	60				
	Text (Group B)	Quiz scores	60	0	10	6.1	2.2
		Valid <i>N</i> (listwise)	60				

**Table R.3***Descriptive Statistics for Summed Quiz Scores (Hydromorphone plus Hydroxyzine) by Format*

Variable	Format		<i>N</i>	Minimum	Maximum	<i>M</i>	<i>SD</i>
Summed Quiz Score	Infographic (Group A)	Quiz scores	120	6	20	14.6	3.2
		Valid <i>N</i> (listwise)	120				
	Text (Group B)	Quiz scores	120	0	18	11.5	3.6
		Valid <i>N</i> (listwise)	120				

**Table R.4***Tests of Normality for Hydromorphone Quiz Scores by Format*

	Format	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	<i>df</i>	Sig.	Statistic	<i>df</i>	Sig.
Quiz Score	Infographic	.17	60	<.001	.94	60	.01
	Text	.13	60	.02	.94	60	.01

**Table R.5***Tests of Normality for Hydroxyzine Quiz Scores by Format*

	Format	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	<i>df</i>	Sig.	Statistic	<i>df</i>	Sig.
Quiz Score	Infographic	.17	60	<.001	.90	60	<.001
	Text	.16	60	<.001	.93	60	.002

**Table R.6***Tests of Normality for Summed Quiz Scores by Format*

	Format	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	<i>df</i>	Sig.	Statistic	<i>df</i>	Sig.
Quiz Score	Infographic	.10	60	.200	.97	60	.200
	Text	.14	60	.008	.96	60	.040

**Table R.7***Levene's Test for Equality of Variances for Hydromorphone Quiz Scores*

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F	Sig.	T	Df
Equal Variances Assumed	.01	.91	-3.89	118
Equal Variances not Assumed			-3.89	117.0

**Table R.8***Levene's Test for Equality of Variances for Hydroxyzine Quiz Scores*

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F	Sig.	T	Df
Equal Variances Assumed	2.55	.11	-5.0	118
Equal Variances not Assumed			-5.0	112.24

**Table R.9***Levene's Test for Equality of Variances for Summed Quiz Scores*

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F	Sig.	T	Df
Equal Variances Assumed	.43	.51	-5.05	118
Equal Variances not Assumed			-5.05	117.03

**Table R.10***Descriptive Statistics for Total Intrinsic Cognitive Load by Format*

Variable	Format		<i>N</i>	Minimum	Maximum	<i>M</i>	<i>SD</i>
Total Intrinsic Cognitive Load	Infographic (Group A)	Intrinsic Cognitive Load	56	0	50	1648	13.66
		Valid <i>N</i> (listwise)	56				
	Text (Group B)	Intrinsic Cognitive Load	58	0	54	22.59	15.88
		Valid <i>N</i> (listwise)	58				

**Table R.11***Descriptive Statistics for Total Extraneous Cognitive Load by Format*

Variable	Format		<i>N</i>	Minimum	Maximum	<i>M</i>	<i>SD</i>
Total Extraneous Cognitive Load	Infographic (Group A)	Extraneous Cognitive Load	56	0	67	15.14	19.22
		Valid <i>N</i> (listwise)	56				
	Text (Group B)	Intrinsic Cognitive Load	58	0	106	26.26	30.65
		Valid <i>N</i> (listwise)	58				

**Table R.12***Descriptive Statistics for Total Germane Cognitive Load by Format*

Variable	Format		<i>N</i>	Minimum	Maximum	<i>M</i>	<i>SD</i>
Total Germane Cognitive Load	Infographic (Group A)	Germane Cognitive Load	56	14	110	79.64	25.02
		Valid <i>N</i> (listwise)	56				
	Text (Group B)	Germane Cognitive Load	58	0	110	68.98	28.02
		Valid <i>N</i> (listwise)	58				

**Table R.13***Tests of Normality for Total Intrinsic Cognitive Load by Format*

	Format	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	<i>df</i>	Sig.	Statistic	<i>df</i>	Sig.
Quiz	Infographic	.14	56	.010	.92	56	.002
Score	Text	.13	58	.012	.93	58	.002

**Table R.14***Tests of Normality for Total Extraneous Cognitive Load by Format*

	Format	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	<i>df</i>	Sig.	Statistic	<i>df</i>	Sig.
Quiz	Infographic	.24	56	<.001	.79	56	<.001
Score	Text	.23	58	<.001	.82	58	<.001

**Table R.15***Tests of Normality for Total Germane Cognitive Load by Format*

	Format	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	<i>df</i>	Sig.	Statistic	<i>df</i>	Sig.
Quiz	Infographic	.16	56	<.001	.92	56	<.001
Score	Text	.07	58	.20	.96	58	.046

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---

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Andersen, M. S., & Makransky, G. (2021). The Validation and Further Development of the Multidimensional Cognitive Load Scale for Physical and Online Lectures (MCLS-POL). *Frontiers in psychology*, 12, 642084. <https://doi.org/10.3389/fpsyg.2021.642084>

My project is evaluating the utility of medication information leaflets prepared either as text, vs. an infographic containing the same information. The participants are informal caregivers of patients with serious illness (hospice patients). I would like to assess their cognitive load as part of this process.

I appreciate your consideration of my request. Thank you!

Mary Lynn McPherson, PharmD, MA, MDE, BCPS  
Professor and Executive Director, Advanced Post-Graduate Education in Palliative Care  
Executive Program Director, Online Master of Science and Graduate Certificate Program in Palliative Care  
Department of Pharmacy Practice and Science  
University of Maryland School of Pharmacy  
20 N. Pine Street, S405, Baltimore, Maryland 21201  
Office 410-706-3682; Cell 443-822-6036; Fax 410-706-4725  
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**Author:** Justin L. Sewell, , , et al  
**Publication:** MEDICAL TEACHER  
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Executive Administrator &  
Special Assistant to the President/CEO  
National Alliance for Caregiving  
1730 Rhode Island Avenue NW, Suite 812  
Washington DC 20036  
[dexter@caregiving.org](mailto:dexter@caregiving.org)  
(202) 918-1013 Direct Dial

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 Special Assistant to the President/CEO  
 National Alliance for Caregiving  
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 Washington DC 20036  
[dexter@caregiving.org](mailto:dexter@caregiving.org)  
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	2020 Prevalence	Estimated Number of U.S. Adults Who Are Caregivers	2015 Prevalence	Estimated Number of U.S. Adults Who Are Caregivers
<b>Overall</b>	21.3%*	53.0 million	18.2%	43.5 million
<b>Caregivers of recipients ages 0-17</b>	5.7%*	14.1 million	4.3%	10.2 million
<b>Caregivers of recipients ages 18+</b>	19.2%*	47.9 million	16.6%	39.8 million
<b>Caregivers of recipients ages 18-49</b>	2.5%	6.1 million	2.3%	5.6 million
<b>Caregivers of recipients ages 50+</b>	16.8%*	41.8 million	14.3%	34.2 million

\* Significantly higher than in 2015.

Mary Lynn McPherson, PharmD, MA, MDE, BCPS  
 Professor and Executive Director, Advanced Post-Graduate Education in Palliative Care  
 Executive Program Director, Online Master of Science and Graduate Certificate Program in Palliative Care  
 Department of Pharmacy Practice and Science  
 University of Maryland School of Pharmacy  
 20 N. Pine Street, S405, Baltimore, Maryland 21201  
 Office 410-706-3682; Cell 443-822-6036; Fax 410-706-4725  
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Best,  
Alex

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Managing Director



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Mary Lynn McPherson, PharmD, MA, MDE, BCPS  
Professor and Executive Director, Advanced Post-Graduate Education in Palliative Care  
Executive Program Director, Online Master of Science and Graduate Certificate Program in Palliative Care  
Department of Pharmacy Practice and Science  
University of Maryland School of Pharmacy  
20 N. Pine Street, S405, Baltimore, Maryland 21201  
Office 410-706-3682; Cell 443-822-6036; Fax 410-706-4725  
[mmcphers@rx.umaryland.edu](mailto:mmcphers@rx.umaryland.edu) \* [@mlmcpherson \(twitter\)](https://twitter.com/mlmcpherson)  
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Mary Lynn McPherson, PharmD, MA, MDE, BCPS  
Professor and Executive Director, Advanced Post-Graduate Education in Palliative Care  
Executive Program Director, Online Master of Science and Graduate Certificate Program  
in Palliative Care  
Department of Pharmacy Practice and Science  
University of Maryland School of Pharmacy  
20 N. Pine Street, S405, Baltimore, Maryland 21201  
Office 410-706-3682; Cell 443-822-6036; Fax 410-706-4725  
[mmcphers@rx.umaryland.edu](mailto:mmcphers@rx.umaryland.edu) \* [@mlmcpherson](https://twitter.com/mlmcpherson) (twitter)  
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