PSYCHOMETRIC ANALYSIS OF THE MEDICAL TERMINOLOGY 350 FINAL TEST USING ITEM ANALYSIS AND KR20

by

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Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

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ABSTRACT

Meaningful quantitative research studies require the use of instruments that have acceptable validity and reliability. The purpose of this study was to determine the reliability and validity of the Medical Terminology 350 Final Test (MT350) in a population of secondary health science students. The MT350 is an assessment instrument that measures participants' recall of medical terminology meanings and is currently being used to assess learning in health science education. A review of literature has revealed a lack of psychometric analysis of the commonly used MT350. Past practice has suggested instruction that uses mnemonics can favorably influence medical vocabulary retention, but an absence of valid and reliable assessment instruments prevented the proper research of the practice. Archival and anonymous data from completed MT350 results was used. Participants in this study consisted of secondary health science students from Tennessee and Missouri with a total sample size of 102 students. Internal consistency was determined through reliability analysis using KR20. Content validity was established through a review by 10 content experts from the fields of health and education. The experts were asked to rate each of the 350 items on a 3-point Likert type scale (3 = essential, 2 = useful, but not essential, 1 = not necessary). It was concluded that the Medical Terminology 350 Final Test (MT350) is a reliable measure of medical terminology retention.

Keywords: mnemonic, student achievement, career and technical education, health science, keyword mnemonic, visual mnemonic, medical terminology

Copyright Page

Dedication

I would like to dedicate this study to my children, Cade and Kinsley. There were times I thought about giving up, but the innocence in both of your eyes gave me the motivation to keep going. My most sincere prayer is for both of you to realize that you can accomplish anything you set your mind to. I will always be understanding and supportive, just as you have been with me through this journey. I love you with all my heart and hope I make you proud. I love you both to the moon and back.

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I would like to thank my family and committee members who have helped me during this process. To my husband, I love you for everything you have done for me and our family. You have completely supported me throughout this process without fail; you are my rock. Thank you for your love, encouragement, and unwavering support. I could not have completed this without you. To my parents, I am forever grateful for all your support—from watching the kids so I could complete my coursework to reminding me that you are cheering me on, helped me to get where I am. I would also like to acknowledge my grandmother who passed away one year before my completion. I can still feel the same love and support she gave me here on earth from heaven.

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List of Abbreviations

Career and Technical Education (CTE)

Cognitive Load Theory (CLT)

Content Validity Index (CVI)

Content Validity Ratio (CVR)

Learning Disabilities (LD)

Learning Style Inventory (LSI)

Medical Terminology (MT)

Medical Terminology 350 (MT350)

No Child Left Behind (NCLB)

Production Effect (PE)

Program of Study (POS)

Vocational Education Act of 1963 (VEA)

CHAPTER ONE: INTRODUCTION

Overview

America's education system seeks to help learners focus on learning towards postsecondary and career readiness (Stone, 2017). The present study explored the psychometric properties of a commonly used classroom learning assessment tool and contributes to the effort to optimize learning in the career and technical education (CTE) realm. The background of career and technical education, curricular challenges and problems, study purpose, significance, research questions, and definitions are presented in this introductory chapter.

Background

The overall goal of CTE is to provide students with employable skills (Rabren, Carpenter, Dunn, & Carney, 2014; Stipanovic, Lewis, & Stringfield, 2012). Given this goal, Stringfield, Shumer, Stipanovic, and Murphy (2013) argued that CTE should utilize the most effective teaching and learning strategies. Wang, Kao, and Liao (2016) and Brahler and Walker (2008) identified the retention of communication skills as a key factor for successfully achieving skills for future employment in health science professions. Students and educators encounter numerous variations in how medical terminology is taught (Wijnen-Meijer, Burdick, Alofs, Burgers, & Ten Cate, 2013). While the literature has supported the need for effective teaching and learning for the retention of knowledge related to medical terminology, it is silent on how best to address best practices for teaching and learning in this area (Hull, 2016).

Historical Overview

Hippocrates established the basis of medical terminology by naming body structures and disorders (Ettinger & Burch, 1999). Hippocrates' contribution of medical terminology led Roman physicians to develop a medical language based from Greek and Latin languages

(Ettinger & Burch, 1999). Unlike the language of medical terminology, secondary health science education is relatively new. Vocational education was integrated into American public schools in the 19th century to provide high-risk students an opportunity to earn a decent living (Castellano, Stringfield, & Stone, 2003) and includes instruction for learning medical terminology. Historically, CTE has targeted low-income and special populations but now involves high levels of participation from higher-income students (Aliaga, Kotamraju, & Stone, 2014), thereby increasing the scope of impact. In its beginning stages, vocational education concentrated on agriculture and trade for boys and homemaking skills for girls (Friedel, 2011). In 1917, the Smiths Hughes Act appropriated $1.7 million for the Federal Board for Vocational Education to oversee state plans (Friedel, 2011). Federal funding and state regulation integrated vocational education into school systems that led to a rapid rise in student participation.

The Vocational Education Act (VEA) of 1963 allotted federal funding for additional training and targeted disadvantaged students (Epperson, 2012). The VEA led to one of the most important legislative components of CTE mandates in the Carl D. Perkins Act that provides equal vocational education access to include occupationally specific courses of study (Friedel, 2011). Today, numerous CTE programs are found in a vast majority of public schools. In 2011, 92% of high school graduates across the state of Tennessee were enrolled in a school that offered CTE programs (Mokher, 2011). CTE include Programs of Study (POS), which are specific pathways that exist in almost every school district in the United States (Stipanovic et al., 2012). Enrolled students are expected to take a predefined collection of classes in a POS that will link them to a CTE concentrator of a specific occupational area, such as health science (Aliaga et al., 2014). Secondary students completing three or more credits in a specific POS determine a CTE concentrator (Aliaga et al., 2014). A POS is an extension of John Dewey's philosophy that

secondary schooling needs to blend school and occupation in preparing students for citizenship and vocation (Stipanovic et al., 2012).

Career and technical education programs continue to strive to meet industry expectations by providing students the industry skills and knowledge to be successful in their careers. The current economy demands higher education and knowledge of trade skills. Health science curricular concepts are aligned with current health profession practices to include technological advances, ethics, professionalism, wellness, diagnostics, therapeutics, and rehabilitation (Health science programs of study, n.d.). Upon completion of a health science program of study, students will be prepared to continue training at the postsecondary level (Tennessee Department of Education, n.d.).

Advances in technology, market demands, and economic demands have transformed many U.S. high schools to shift from traditional programs to health and computer technology (Aliaga et al., 2014). In Oklahoma, more than 40% of sixth to 12th grade students are enrolled in a career tech program. Additionally, graduates of an Oklahoma's career tech program add more than $3.5 million to the state's budget annually (State of Oklahoma, n.d.). The health science career specialty/occupation career cluster exists within CTE and is further divided into specific programs of study. It is essential for CTE curriculum, instruction, and research to conform to the anticipated shifts in the workplace (Rojewski & Hill, 2014).

Social Impact

Society demands a work force to be well educated and skilled and may offer jobs in which the individual will contribute to society (Wüst, 2015). Providing students with technical skills during high school to efficiently transition students to adulthood is the foundation of CTE (Loera, Nakamoto, Jon-Oh, & Rueda, 2013). Loera et al. (2013) argued that society values

academic preparation that conforms to society trends and expectations. CTE aims to help adolescents gain the knowledge and experiential learning needed for employment (Loera et al., 2013).

Preparation of secondary students to succeed in postsecondary schooling should be a core concern of career and technical educators. There are specific factors that curriculum leaders should consider in the curriculum development process (Parkay, Anctil, & Hass, 2014). Factors that curriculum leaders should consider include (1) a balance of content, (2) effective sequencing, and (3) activation of student's prior knowledge (Parkay et al., 2014). Medical Terminology 350 delivers content by sequencing medical elements using a small quantifiable goal of 25 meanings while activating students' prior knowledge of illogical picture associations. One of the most effective ways for CTE educators to prepare students for the challenges of society is through the selection of appropriate and meaningful instructional strategies that engage the student (Fletcher & Djajalaksana, 2014). Equipping students with a sound medical terminology foundation may benefit society through learner societal readiness in the postsecondary and industry setting.

Theoretical Framework

Learning theories drive preferred pedagogies of educational constituents who directly influence student learning. While numerous learning theories encouragingly influence student learning, the cognitive load theory (CLT) is influential in student engagement using learning activities that scaffold retention in short-term and long-term memory. CLT relates directly to medical terminology instructional techniques by creating schemas to establish long-term memory of medical terminology. The Dean Vaughn Total Retention System is one example of a method for students to manage cognitive resources while learning medical terminology.

CLT involves human memory built on sensory, working, and long-term memory, with working memory only able to process a limited amount of information at a time; once working memory has reached its capacity, failure of learning will ensue (Young, Van Merriënboer, Durning, & Ten Cate, 2014). The three types of cognitive load are as follows: (1) performing essential learning tasks (intrinsic), (2) performing non-essential tasks (extrinsic), and (3) an intentional use of cognitive strategies to facilitate learning (germane; Young et al., 2014). CLT is highly relevant in medical education due to learning that occurs through simultaneous integration of varied sets of knowledge (Young et al., 2014), thereby aligning with the three types of cognitive load.

Constructed knowledge is often the product of learning by creating new constructs in which the learner is active in learning, as noted in the CLT and the constructivist learning theory. Developed by Jean Piaget, the CLT is an active learning theory through which students actively engage and participate in their learning. According to Suchman, Uchiyama, Smith, and Bender (2006), CLT is based on a learning environment that is interpretive, recursive, and built on a process where learners actively participate to make meaning of new information and constructs.

Problem Statement

The literature to date does not adequately address the issue of best teaching and learning practice for students in health science, yet students' learning plays an important role in their success in the classroom and beyond (Shoemaker & Kelly, 2015). Specifically, there is a lack of psychometric data for the Medical Terminology 350 Final Test (MT350). Without a valid and reliable assessment tool, quantitative studies have not been possible to measure best teaching and learning practices. Quantitative studies using a validated MT350 have not been possible to measure medical terminology retention.

It is necessary for educators to establish best teaching and assessment practices to develop student learning in subject areas that are necessary in college and career, such as medical terminology. To explore student learning, a valid and reliable tool is imperative, and to date, this work has not been done.

Due to its diverse origins, medical terminology is a multifaceted and perplexing field of study (Wang et al., 2016). Knowledge of technical and medical terminology is an educational need and prerequisite to being able to solve problems in students' future healthcare careers (Brahler & Walker, 2008).

Health science teachers often neglect fundamental teacher preparation that may source ineffectual instructional practices (Fletcher & Djajalaksana, 2014). The lack of fundamental preparation may foster deficient pedagogical knowledge, resulting in difficulty accommodating students' educational needs and the potential of not delivering effective lesson plans (Bowen, 2013). Teachers reported that instructional practices that do not work lack student engagement, lack depth, and obstruct student engagement and the student's ability to conceptualize specific concepts (Sandholtz, 2011). The pedagogical values of visual instructional techniques motivate the student and stimulate creativity to flourish learning (Kordjazi, 2014).

Mnemonics can be a useful pedagogical tool devised of memory strategies that organize and chunk information to enhance encoding and facilitate retrieval (McCabe, Osha, Roche, & Susser, 2013). Memorization strategies help students learn, understand, and memorize vocabulary (Wang et al., 2016). Originating from mnemonics, the keyword mnemonic method significantly affects students' vocabulary retention (Davoudi & Yousefi, 2016). There are no identifiable studies to date that report whether or to what extent the keyword mnemonic method is taught in teacher preparation courses (Dolean, 2014). In relation to keyword mnemonics, an

interview of postsecondary students revealed that the majority of those interviewed knew only one type of mnemonic (Stephens & Moxham, 2016). An exposure to an assortment of mnemonics at the secondary level may provide unconventional learning tactics for students in postsecondary education.

Numerous studies have confirmed the benefit of using the keyword mnemonic method as a vocabulary instructional strategy (Davoudi & Yousefi, 2016; Dolean, 2014; Hussein & Jakubec, 2014; McCabe, 2015; McCabe, Osha, Roche, & Susser, 2013; Siriganjanavong, 2013; Yang & Dai, 2012). Thus far, Brahler and Walker (2008) have conducted the only research to examine the keyword mnemonic method using the Medical Terminology 350 Total Retention System. Brahler and Walker's research examined a sample of secondary anatomy and physiology students, signifying a void among examining secondary health science students. Sagarra and Alba (2006) recommended a study to examine if more advanced second language learners learn better with memorization or the keyword method. The problem is that keyword mnemonics is understudied as a viable instructional delivery strategy because of the absence of a valid and reliable measurement tool.

Purpose Statement

The purpose of this study is to determine the reliability and validity of the Medical Terminology 350 Final Test (MT350) in a population of secondary health science students. In doing so, it can be determined if this instrument can be used in future investigations on best teaching and learning strategies for keyword mnemonic methods.

It is vital to evaluate the MT350 instrument for the following reasons: (a) the importance of medical terminology knowledge to the healthcare profession, (b) the importance of effective vocabulary instructional strategies, (c) the importance of the cognitive load theory in learning

vocabulary, and (d) the need for a confirmed reliable and valid instrument to measure medical terminology retention using the keyword mnemonic method. Examining learning medical terminology through keyword mnemonics includes how instructional strategy influences long-term retention. Hussein and Jakubec (2014) proposed that future studies examine the effectiveness of repetition of a mnemonic device along with the use of various strategies such as visual aids.

This study fills a gap in the literature by identifying the validity and reliability of the MT350 among secondary health science students. Acceptable reliability is greater than or equal to .70 (Laurie & Sloat, 2016; Reeve et al., 2007). According to CoPo (2015), "A valid test is also a reliable test but a reliable test may not be a valid one" (p. 189); thus, this study explored both the validity and reliability of the MT350.

Significance of the Study

In order to promote medical terminology retention, educators need to be able to employ effective instructional strategies. One stratagem of vocabulary instruction is the keyword mnemonic method. The Dean Vaughn Total Retention System uses a mnemonic memory system in its MT350 course to instruct participants through the keyword mnemonic method. Currently the MT350 instrument has not been psychometrically evaluated to determine its reliability and validity. Confirmation of the reliability and validity of instruments to assess student learning is a prerequisite of assuring integrity of research findings (DeVon et al., 2007). The foundation of rigorous research concerning effective instructional practices is the use of a psychometrically sound instrument (DeVon et al., 2007).

When a program combines academic rigor with industry-based technical content, students have higher academic achievement and better economic outcomes (Wilkin & Nwoke,

2011). Performance regarding medical school selection outcomes has also been found to improve when students prepare through training activities (Laurence, Zajac, Lorimer, Turnbull, & Sumner, 2013). Poor collegiate medical terminology achievement has recently led secondary health science teachers to suggest a gateway course as a prerequisite to medical terminology (Ryan, 2011). Students who enter college with an established familiarity of medical terminology may avoid a medical terminology gateway course. This study adds to the research by providing an evidence-based reliable instrument to measure medical terminology recall among secondary students interested in the medical field.

Keyword mnemonics may improve learning retention for individuals in the education field (The Dean Vaughn Total Retention System, 2017) and have a broader application beyond the health sciences. Theoretically, keyword mnemonics simplifies difficult medical terms by managing essential learning tasks while optimizing the use of cognitive learning strategies to build word associations (Young et al., 2014). This study adds to the CLT literature by exploring the psychometric properties of an assessment tool, thereby facilitating important future research into the use of keyword mnemonics for health science curricula. Evidence-based vocabulary instructional strategies linked to a learning theory are more productive and beneficial then non-theoretical based strategies (Kennedy, Deshler, & Lloyd, 2015). Findings of an evidence-based reliable instrument to measure medical terminology recall may result in a curricula directional shift in health science programs.

Research Questions

RQ1: Is the MT350 a valid instrument to assess medical terminology retention learned by the keyword mnemonic method among secondary health science students?

RQ2: Is the MT350 a reliable instrument to assess medical terminology retention learned by the keyword mnemonic method among secondary health science students?

Definitions

1. *Career and Technical Education* –A learning model which promotes student career-readiness (Rojewski & Hill, 2014).
2. *Curriculum* – "The curriculum of any educational system is planned and developed according to the needs of the society. Just as the society is dynamic, the curriculum is also dynamic" (Festus & Kurumeh, 2015, p. 62).
3. *Keyword Mnemonics* – Facilitates learning new vocabulary words by creating an acoustic and imagery link between a familiar and unfamiliar word (Dolean, 2014).
4. *Learning styles* - The mental processes and instrumental settings a student uses most effectively while learning that allow the learner to learn differently and distinctively (Sadeghi, Mohd Kasim, Hoon Tan, & Sathi Abdullah, 2012).
5. *Mnemonics* – "Memory strategies that help meaningfully organize and chunk to-be-learned information" (McCabe, Osha, Roche, & Susser, 2013, p. 183).
6. *Psychometric Statistics* – *"*The psychometric properties of scores and the appropriateness of interpretations and uses of outcomes from test and other measures" (Gall, Gall, & Borg, 2007).
7. *Reliability* – the extent to which a test yields the same result on repeated measures (CoPo, 2015).
8. *Rote Learning* – A learning technique based on memorization rather than understanding the content (Tokuhama-Espinosa, 2011).
9. *Rote Memorization* – Learning by repetition (Khoii & Sharififar, 2013).

10. *Test Reliability* – The consistency, stability, and precision of test scores (Gall et al., 2007) as calculated for the MT350 using a .70 cutoff, as described in Chapter 3.
11. *Test Validity* – The appropriateness, meaningfulness, and usefulness of specific inferences made from test scores (Gall et al., 2007) on the MT350 will be evaluated by a panel of content experts using the content validity ratio, as described in Chapter 3.

CHAPTER TWO: LITERATURE REVIEW

Overview

The literature does not adequately address the issue of best teaching and learning practice for students' acquisition of medical terminology, yet students' learning plays an important role in their success in the classroom and beyond (Shoemaker & Kelly, 2015). Specifically, there is a lack of psychometric studies to examine the Medical Terminology 350 Final Test (MT350). Without a valid and reliable assessment tool, conclusive studies on the topic of student acquisition and retention of medical terminology are not possible.

In this literature review, common teaching practices in medical terminology (MT) instruction, retention, and the theories upon which they are based are examined. The literature review reveals a scarcity of quality empirical analyses on reliable instruments that measure students' retention of medical terminology. The absence of a well-validated and reliable instrument to measure students' retention of medical terminology was the reason for this study.

Theoretical Framework

Literature describing the importance of assessing student learning in health science studies is ubiquitous (Brown, White, & Power, 2016; Castillo-López et al., 2014), yet studies that include valid and reliable instruments are rare. CoPo (2015) noted that quantitative study must include instruments with sound psychometric properties.

It is imperative to understand the variations concerning how students process and retain information; to study this concept, sound assessment instruments must be used. Strayer et al. (2011) and Holmes (2018) provide examples of studies used to establish psychometric properties for various education and assessment instruments. Many reasons are currently discussed to support the importance of health science education. Authors have investigated the working

potential of the brain to learn more about the physiological basis of learning (Hessler & Henderson, 2013). Cognitive load helps to accumulate information to be stored into long-term memory (Hessler & Henderson, 2013). Long-term memory is achieved through a progression of short-term memory-to-memory load. Memory load is a foundational building block to the architecture of a cognitive schema, making it necessary for educators to be cognitive of instruction presentation. Critical thinking and analyzing abilities may decrease the number of elements a student may achieve due to being more demanding in cognitive processing.

Cognitive load theory (CLT) alludes to schemata construction being best regulated by decreasing extraneous load, managing intrinsic load, and optimizing germane load (Young et al., 2014). The keyword mnemonic method may facilitate schemata construction through a simplistic yet illogical visual mnemonic approach to medical education. Through multimedia implementation of keyword mnemonics, extraneous loads may be decreased by reduced disruptions attributed to students engaging with the instructional video. Lastly, keyword mnemonics simplifies difficult medical terms by managing the intrinsic load, and seeks to optimize germane load by building word associations with an audionym and meaning. Word associations are often successfully and purposely assimilated within technology.

Cognitive Load Theory and Technology

Instructional animations play a major role in teaching medical information due to simulating real-life conditions. Yue, Kim, Ogawa, Stark, and Kim (2013) performed a comprehensive review of instructional animations in the health sciences domain and concluded that there is still much needed improvement for the efficiency of animations in medical education. Medical animations contribute to the cognitive theory of multimedia learning but there is still much that needs to be investigated (Yue et al., 2013). The Dean Vaughn Total

Retention System uses instructional animations to associate the element with its aligned audionym. CLT implies that students would best learn medical terminology by building mental schemes through multimedia learning. Medical animations are a newer module that is positively benefiting the medical field, but due to its infancy, there is much research needed.

Computer-based learning environments may additionally influence student achievement and cognitive load (Liu & Su, 2010). Cognitive load was found to increase with multimedia learning tasks, and learning cognitive resources were more efficient through computer-based learning compared to traditional learning (Liu & Su, 2010). Liu and Su (2010) provided a strong theoretical framework for the benefit of germane cognitive load. There seemed to be more strengths than weaknesses for the use of multimedia compared to traditional instruction. There is strong support regarding supplementing the use of multimedia in instruction with simulations. The effectiveness of instructional designs may be determined by the capability of keeping intrinsic and extraneous cognitive load to within the learner's working memory limits (Wong, Leahy, Marcus, & Sweller, 2012). Through the use of modalities such as listening to words while looking at a picture, the intrinsic load may be high while maximizing learning occurs (Müller, 2012). Educators should minimize the stress of cognitive load to adjust to the learner's memory working capacity.

Cognitive Load Theory Applied

Cognitive load assists in creating schemas for students to store in long-term memory. A benefit that is suspected of keyword mnemonics is that cognitive load may create schemas for students to have a long-lasting retention of medical terminology. Schematic construction organizes a pattern that reflects interactions with the environment (Miller, 2011). Sadoski, McTigue, and Paivio (2012) explained that the dual coding theory also supports the cognitive

load theory by utilizing a multimodal reading, composing, and spelling strategy. The practice of combing the written and spoken forms of a word can have beneficial results for MT retention (Müller, 2012). Repeated exposure may improve processing speed and strengthen representational processing between visual and phonological associations (Müller, 2012). An audiovisual means of providing repeated exposure to spoken and written vocabulary may improve long-term retention. Structuralism framework can be seen in how cognitive schemas and operations formulate themselves into an organized whole and can be applied to content (Müller, 2012). CLT relates directly to this research by creating schemas to establish long-term medical terminology retention. Learning achievement and cognitive load level can be factors to further investigate students' efficiency to manage learning in a multimedia environment (Liu & Su, 2010).

The key element of managing cognitive resources in multimedia learning is vital in determining effectiveness. A study was conducted to outline a strategy used in a hospital to maximize the knowledge transfer to referring physicians on using a picture archiving and communication system and found that a holistic adoption of CLT techniques may safeguard physicians' main mental processes (Devolder et al., 2009). Methods in which CLT can be utilized through keyword mnemonics contain variations of e-learning such as instructional animations.

Instructional animations may act as a learning catalyst while improper use may encumber vocabulary learning. There is considerable interest and attention towards cognitive load attainment in vocabulary learning and recall. When presenting visual stimuli, it may benefit student learning if teachers cognize the effects of differing visual stimuli on cognitive load. Çetin, Griffiths, Özel, and Kinay (2014) sought to determine the effects of affective stimuli on

cognitive load among students aged 17–25 learning foreign language vocabulary. Affective overload in vocabulary learning occurs when learning is negatively affected due to students experiencing strong emotions (Çetin et al., 2014). All participants were shown target vocabulary words with a picture, audio, and in written form (Çetin et al., 2014). After viewing the target words, students viewed with visually affective content of neutral content (Çetin et al., 2014). Students who viewed the visually affective content which was violent or frightening had significantly less recall (Çetin et al., 2014). Much like learning through the keyword mnemonic method, students were shown a picture while hearing the word. The research by Çetin et al. (2014) implies that offensive or threatening images may impede vocabulary learning due to consuming a large amount of working memory. It can be suggested that neutral or positively entertaining visual stimuli may not increase cognitive load and obstruct learning.

Increased Cognitive Load

An overbearing cognitive load is negatively consequential on student learning. There needs to be a balance of cognitive load where the student can transmit information to long-term memory. Inappropriate use of educational methods may increase cognitive load and produce negative learning outcomes (Qiao et al., 2014), such as insignificant critical thinking and memorization. Knowing that research has proven students have better success from creating schemas based on previous experiences should encourage educators to be proactive in steadily building knowledge retention. Representational animations are often used to promote improved vocabulary learning performance. A group of collegiate second language learners was shown a representational video while the word was described through narration (Mayer, Lee, & Peebles, 2014). The representational video and narration resulted in improved performance on a vocabulary assessment which Mayer et al. (2014) contributed to providing additional access to

the word without creating extraneous cognitive load. On-screen captions were then added to the representational video but did not improve vocabulary test performance (Mayer et al., 2014). On-screen captions may overload a student's memory capacity, consequently overloading cognition capabilities (Mayer et al., 2014). Vocabulary instructional designs should account for constructing and obstructing factors to optimize cognitive load.

Cognitive Load Theory and Instructional Designs

MT retention may best serve the student when a vast quantity of schemes occupy long-term memory. A complex set of interacting elements are incorporated into working memory due to schemas and the accessibility of those schemas through unconscious properties (Paas, Renkl, & Sweller, 2003). Cognitive schematic is information storage in long-term memory that provides easy learning recognition and saves working capacity (Cheon & Grant, 2012). Educators should take the cognitive load theory framework into consideration when developing instructional strategies. It is appropriate to decrease educator control and increase learner control while utilizing learner strategies to reach individual goals (Paas et al., 2003). Learners' goals can accelerate vocabulary knowledge while effectively employing the cognitive load theory to aid in long-term retention. A multimedia learning environment may not always be a feasible design while a measurement of cognitive load may be necessitated to illuminate the learner's performance. A group of first year college physics students (20–23 years old) demonstrated better recall of technical vocabulary through the use of multimedia presentation compared to the traditional use of a teacher presentation (Rusanganwa, 2013). Multimedia may be effective when extraneous loads are decreased and redundant on-screen texts are removed (Rusanganwa, 2013). Vocabulary reaction time may also provide a direct measure of cognitive load while engaged in multi-media instruction (Paas et al., 2003). Multimedia may accentuate cognitive

load instead of producing a negative load to the working memory. Immediate vocabulary recall rehearsal may assist students' working memory to avoid excessive cognitive load.

Cognitive Load Theory Among Health Professionals

Instructional approaches in health professions have stressed authentic learning tasks until recently, in which the cognitive load theory is being used to teach complex domains (Van Merriënboer & Sweller, 2010). Medical professional students are considered expert learners by mindfully combing simple ideas into more complex ones (Van Merriënboer & Sweller, 2010). Fully automated schemas are developed by extensive practice (Van Merriënboer & Sweller, 2010), supporting the need to have secondary and postsecondary students repeatedly practice medical terminology to assist with complex ideas. Van Merriënboer and Sweller (2010) presented strategies to benefit the cognitive load theory such as the following: Replace a written explanatory test and another source of visual information with a spoken text and visual source, gradually work up to tasks in full complexity, and replace separated completion tasks with enriched ones containing prompts. These strategies imply that when learning difficult vocabulary, it is best to see and speak the word, start with simple components of the word, and incorporate prompts.

Constructivist Learning Theory

Constructivism is a meaning-making theory (Ultanir, 2012) which seeks to understand the world through students' learning preferences (Creswell, 2013). The constructivist learning theory posits learning through constructs and scaffolding that promote student academic enrichment by restructuring new knowledge. Anthony (1996) explained that constructivism is an idiosyncratic, active, and evolving process that is operationalized by cognitive and metacognitive learning strategies.

Constructivist learning theory rests on an active learning environment where new learning is constructed by the learner relating prior knowledge and experience (Friberg, 2001). Active learning participation has been found to keep learners engaged for a longer period of time (Kablan & Kaya, 2014), such as those in a constructivist approach of building new knowledge structure. The constructivist learning theory presents four strategies that students use to process new learning content, selection, rehearsal, organization, and elaboration (Friberg, 2001). The constructivist learning theory also works jointly with other learning theories to optimize student learning. Hsieh, Hsu, and Huang (2016) designed a nursing education program on evidence-based practices, constructivism, and the cognitive load theory and concluded that the combination of learning strategies increased mental effort, mental efficiency, and research knowledge.

Meaningful learning activities stimulate prior knowledge, which encourages a new interest in learning (Bevevino, Dengel, & Adams, 1999). Based on the constructivist learning theory, learning activities engage students to uncover inconsistencies between new content and previous experiences (Keengwe, Onchwari, & Agamba, 2014). A constructivist approach suggests that an introduction to new medical vocabulary would cause the students to reflect on the meaning from past learning. Similar to medical terminology, anatomy is one of the oldest basic medical sciences that has been taught in a routinely traditional manner (Mota, Mata, & Aversi-Ferreira, 2010). Alternative constructivist pedagogic methodologies compared to traditional teaching proved more significant in difficult courses such as anatomy (Mota et al., 2010). The keyword mnemonic method is an effective pedagogic method in increasing meaningfulness and connecting new information to prior knowledge (Kleinheksel & Summy, 2003). When introduced to new terminology, the keyword mnemonic method and constructivist

learning theory both reconstruct the vocabulary from something familiar, relate the new vocabulary, and retrieve the vocabulary from a new construct (Kleinheksel & Summy, 2003). The keyword mnemonic method allows a student to easily recognize a word and apply the meaning in context (Siriganjanavong, 2013).

Experiential Learning Theory

From Freud to Erikson, there are psychological theories that endeavor to define and cognize human learning development. An experientialist approach to curriculum is founded on the interests and skills of the learner and is less systematic and based on natural learning. The natural learning occurs from the learner's freedom to learn in a manner that is of interest and preference. Kolb's experiential learning theory (ELT) is one of many learning theories that attempts to categorically rationalize human learning.

Founded on works of Dewey, Lewin, and Piaget, Kolb developed ELT and the Learning Style Inventory (LSI). "Unlike cognitive learning theories, which tend to emphasize cognition over affect, and behavioral learning theories, which do not allow any role for consciousness and subjective experience in the learning process, experiences play a central role in ELT's process" (McCarthy, 2010, p. 132). The ELT presents learning styles that shape a student's learning style. According to Kolb, research has found that learning styles are influenced by personality type, educational, career choice, current job role, and cultural influences (as cited in McCarthy, 2010). The ELT depicts learning has a cyclical process that is designed by learning experiences. Experiential learning constructs knowledge through a four-stage learning model. According to McCarthy (2010), the four-stage learning model is made of concrete experience, abstract conceptualization, reflective observation, and active experimentation. Learning is developed through each stage being performed by the learner. Though the learner uses all stages, he or she

will eventually use preferred stage(s) more frequently. The ELT describes how a learner learns, while the Kolb's LSI describes the learner's learning style.

Knowledge of students' learning styles may be useful to CTE educators to diversify instruction through strategies that enhance the learning experience (Threeton & Walter, 2009). Though not all students in a particular discipline will have similar learning styles, cumulative learning style trends may be used as indicators for MT curriculum development. Students commonly use a specific learning mode when confronted with a learning stimulus (Nuzhat, Salem, Hamdan, & Ashour, 2013). Literature has exposed an essentially important component of curriculum development in the form of integrating students' learning style preferences into curriculum design and instructional strategies (Hussein & Jakubec, 2014). MT curriculum should enable instructional strategies to be manipulated in a manner that gives teachers' the ability to have a multidimensional approach to instruction. This approach accounts for student differences and enables an effective learning environment where students may intellectually thrive. Knowing students' predominant learning style may foster an active learning environment where best MT instructional strategies meet the learning preferences of health science students.

Related Literature

Learning Characteristics of Health Science Students

Learning styles serve as stable indicators concerning how learners' perceive, interact, and respond to a learning environment (Conti & McNeil, 2011). Consequently, there is a requisite need to identify learning strategies that conform to students' learning styles. Learning strategies are techniques used to accomplish a learning task (Conti & McNeil, 2011). Knowledge of health science students' learning styles may generate MT curriculum development that is reflective of academic success. Dumford, Cogswell, and Miller (2016) used data from the National Survey of

Student Engagement to determine congruency in academic disciplines between the student use and faculty encouragement of learning strategies. First-year students and lower division faculty of those majoring in or primarily instructing health profession and social services tended to cluster near the top of the scores (Dumford et al., 2016).

There is sufficient evidence indicative of the influence and variability of learning styles on academic achievement. Inversely, a lack of sufficient evidence concerning secondary health science students in the traditional classroom endures. The diverse nature of student preferences and learning diversity was examined among a group of 82 senior-allied health students at a large university (Cox, Clutter, Sergakis, & Harris, 2013). Learning styles were found to change between the classroom and clinical setting while varying between allied health majors (Cox et al., 2013). Pre-clinical allied health students were also found to have significant correlations for kinesthetic preference using visual-aural-read/write-kinesthetic inventory (Good, Ramos, & D'Amore, 2013). The findings pertaining to postsecondary-allied health students may simulate potential findings of secondary health science students. Variances across disciplines substantiate the need for instructors to create learning strategies supportive of a structured learning environment that is specific to MT instruction.

Psychometric Analysis in Teaching and Learning

Psychometric analysis of instruments used in teaching and learning is not a new practice (CoPo, 2015; Kara & Celikler, 2015; Lee & Wimmers, 2015; Spencer, Goldstein, Kelley, Sherman, & McCune, 2017). A good test should be a valid and reliable measure of student proficiency (CoPo, 2015). Psychometric analysis evaluates the quality of an instrument and is a common interest in educational research. Instruments such a language preschool comprehension assessment is one of the many examples of psychometric analysis of an educational assessment.

The assessment of story comprehension (ASC) was found valid and reliable to measure preschoolers' causal and predictive inference skills (Spencer et al., 2017). Spencer et al. (2017) found construct validity correlation from 0.67 to 0.81 by correlating the ASC with two other language measure instruments. From preschool to medical school, psychometric analysis of assessment instruments is essential. Four domains of a problem-based learning (PBL) assessment used in medical school was evaluated (N = 310) and found to be valid and reliable (Lee & Wimmers, 2015). Correlations between PBL domain scores and outcome measures found construct validity partially supported (Lee & Wimmers, 2015). Psychometric analysis also revealed PBL performance can be predictive of medical school achievements (Lee & Wimmers, 2015).

Variations of item analysis in psychometric analysis are noted throughout research (CoPo, 2015; Kara & Celikler, 2015). Item analysis is a common way to determine the appropriateness of a test question. Kara and Celikler (2015) used item analysis to eliminate questions on a fifth-grade science achievement test when question distinctiveness was low (0.30). After the elimination of the questions, Kuder-Richardson Formula 20 (KR20) found the MT350 to be a reliable instrument (0.763). Content validity of the achievement test instruments was determined from the opinions of four reviewers. The panel of reviewers approved the achievement test to be suitable and appropriate. Unlike Kara and Celikler (2015) who used subjective opinions with KR20, CoPo (2015) conducted a split-half reliability analysis with the KR20.

The split-half reliability coefficient of a business statistics course test instrument was found low (r = 0.67) yet found reliable from the KR20 (r = 0.67). Halving a test, such as the split-half reliability, decreases reliability (CoPo, 2015). The KR20 is often used with the split-

half reliability to account for the projected low reliability (CoPo, 2015). Simultaneously, item analysis determines difficulty and discrimination level. Difficulty level (*p*) of a test item calculates the number of students who answered the question correctly divided by the total number of students (CoPo, 2015). Test item difficulty level of 40% to 80% is acceptable (CoPo, 2015). Test scores for the business statistics course instrument were found valid and reliable (CoPo, 2015). Psychometric analysis is a multifaceted progression that utilizes various evaluation methods to achieve a common goal of determining validity and reliability.

Psychometric properties of a Safe Administration of Medications-Revised (SAM-R) scale was analyzed to determine the validity and reliability in assessing nursing students' knowledge to safely deliver medications (Bravo, Pozehl, & Kupzyk, 2016). Evidence was obtained for reliability, face, content, and construct validity on the SAM-R, a dichotomous response assessment (Bravo et al., 2016). Cronbach's alpha (.736) determined the reliability of the SAM-R (Bravo et al., 2016). Face validity of the SAM-R's readability was determined by senior level nursing students, whereas content validity was determined from eight faculty experts (Bravo et al., 2016). An independent *t*-test of the SAM-R scores from junior and senior students evaluated construct validity (Bravo et al., 2016). The SAM-R was found to be a valid and reliable instrument, but according to Bravo et al. (2016) had an insufficient sample of 227. Though it was stated $N = 227$ was a limitation, a recommended sample size failed to be provided.

A 24-item tool titled the Assessment of Critical Thinking in Midwifery (CACTiM) was developed and tested to determine its validity and reliability in assessing undergraduate midwifery students' critical thinking in practice (Carter, Creedy, & Sidebotham, 2016). Members of an expert panel completed a Content Validity Index (CVI) by rating each item on the CACTiM (1 = not relevant to 4 = relevant) and determined the proportion of items rated by

experts as either 3 or 4; a CVI above 0.8 was considered to be valid (Carter et al., 2016). Construct validity was determined by factor analysis and internal reliability with a Cronbach alpha coefficient (0.97; Carter et al., 2016). Similar to the psychometric testing of Bravo et al. (2016), content validity was determined by a panel of experts and reliability using Cronbach alpha. Bravo et al. (2016) used an independent *t*-test of student scores to determined construct validity while Carter et al. (2016) used factor analysis. A homogenous sample population (Bravo et al., 2016; Carter et al., 2016) may be a limitation in lack of participant diversity in psychometric testing.

Instruments used to asses learning in health education are commonly evaluated for psychometric properties (Bravo et al., 2016; Carter et al., 2016; Wu, Enskär, Pua, Heng &Wang, 2016). Reeve et al. (2007) presented the importance of evaluating Patient-Reported Outcomes Measurement Information System (PROMIS). Psychometric evaluation of the PROMIS consisted largely of descriptive statistics and item response theory (IRT) model assumptions (Reeve et al., 2007). Cronbach's alpha determined internal consistency reliability, but the authors could not use it to determine unidimensionality. Unidimensionality is an assumption of IRT models that a person's response on a construct accounts for the person's trait and not by other factors (Reeve et al., 2007). The PROMIS was not evaluated for face or content validity.

Wu et al. (2016) evaluated the psychometric properties (content validity, factor structure, internal consistency, and test-retest reliability) of a Holistic Clinical Assessment (HCAT) to assess undergraduate nursing clinical competency. Similar to other psychometric studies (Carter et al., 2016), content validity was subjectively and objectively determined by a panel of experts. Contrary to Carter et al. (2016), Wu et al. (2016) utilized two different panels to evaluate the face and content validity. The Content Validity Index (CVI) was determined by a common

psychometric 4-point scale (Carter et al., 2016), but Wu et al. (2016) determined the CVI by calculating the Item Content Validity (I-CVI) and Scale Content Validity (S-CVI). While the sample size was relatively small (*N*=130), the students' practical settings widely varied (Wu et al., 2016). The internal consistency and test-retest reliability was satisfactory with Cronbach alpha ranging from .789 to .965 (Wu et al., 2016). Test-retest reliability provides an additional psychometric aspect to be evaluated but may not be accessible with archival data.

Linguistic bias necessitates psychometric properties of an instrument in a different language to be evaluated. Laurie and Sloat (2016) evaluated the French Early Years Evaluation-Teacher Assessment (FEYE-TA) to determine if it was a valid and reliable instrument. Data analysis addressed the FEYE-TA's internal consistency reliability, content validity, construct validity, concurrent validity, and discriminant validity (Laurie & Sloat, 2016). Internal consistency reliability yielded a satisfactory Cronbach's alpha of .70 (Laurie & Sloat, 2016). Psychometric evaluation should account for student learning differences in content and construct.

Health Science Instruction Development

As technology continues to progress in advancements, technologies parallel with education are a necessity to encourage active learning. The integration of technology was found effective in vocabulary development while students were also more engaged in class activities (Huang, 2014). It is imperative that research is capable of substantiating ways and means to conjoin learning and technology to maintain relevancy. A technology-based teaching strategy is a highly effective approach (Lumpkin, Achen, & Dodd, 2015). Chen (2015) emphasized the need to create an appropriate learning environment based on instructional designers and instructors knowing how to shape the environment. Chen investigated the relationship between online social networking, learning styles, and participants' perceptions towards mobile

Facebook. Chen found that there was no significant difference in test scores among different learning style groups. Findings did conclude that a significant difference in attitudes towards learning in the mobile Facebook environment existed among different learning styles (Chen, 2015). Students in the assimilating group and diverging group scored higher in self-efficacy towards learning in mobile Facebook (Chen, 2015). Chen concluded that the assimilating and diverging group outpaced the other group inferring that learning styles in the reflective observation (RO) dimension benefited more from learning through Facebook. This study implies that certain learning styles prefer a social technological learning environment, but not all. Learning MT may be enriched when students incorporate a social-networking learning environment.

Synonymous with learning styles, cognitive styles are processing conducts that describes mode of thinking. State and federal mandates are currently causing a shift in today's education system, so evaluation of curriculum is not only needed but necessary. It takes considerable effort of intellect to decipher through educational reform that will ultimately affect curriculum (Kinder, 2013). Developing curriculum specific to MT may be a tiresome and detailed process but will yield much reward to the student and educational constituents. Priorities in the curriculum development should center on practical concerns. Teachers' explicit design reasoning is mostly influenced by practical concerns, yet their own knowledge and beliefs play an important role at the start of the design process (Boschman, McKenney, & Voogt, 2014). The design and developmental process needs to be a strategic process that addresses specific concerns, such as specific instructional strategies to enable efficient MT retention. A search of the literature for valid and reliable instruments to measure this domain demonstrated an absence of studies and thereby a gap in the literature.

Medical Terminology (MT)

MT is the communal language articulated by healthcare and science professionals who use this language to help communicate observations clearly, concisely, and effectively (Stanhope & Turnbull, 2016). Healthcare workers use MT in everyday work to record orders, write instructions, take notes, and to chart (Badasch & Chesebro, 2011). MT creates an operative language based on classical vocabulary roots and forms word elements. Establishing elements to build medical terms is a common practice in the medical field. Medical terms are formed from the combination of one or more basic word parts to include root words and combining vowels, prefixes, and suffixes (Stanhope & Turnbull, 2016).

It is inferred that a knowledgeable foundation of the Latin and Greek roots in MT may also improve anatomy and physiology learning (Pampush & Petto, 2016). This presumption was not supported by Pampush and Petto (2010), who found a weak correlation between Latin and Greek assessment score and performance on anatomy assignments when studying undergraduates in their first semester of anatomy and physiology. This study did not directly state the level of Latin and Greek roots in the specific assignment. MT is a component in the formation of medical language. Medical language is a universal construct in today's multilingual healthcare environment and is a prerequisite to for effective communication (Hull, 2016). An in-depth knowledge of MT is necessitated not only amongst healthcare providers but also between the provider and patient. According to Hull (2016), patient safety may be compromised through treatment and medication error when there is poor medical language proficiency.

The majority of elements needed to master MT is abstract and unfamiliar (Vaughn, 2004). The Dean Vaughn Total Retention System converts the abstract information into images of real and familiar objects and associates them with the subject (Vaughn, 2004). Currently, only

one peer-reviewed study has specifically examined the Dean Vaughn Total Retention System in relation to MT retention. Brahler and Walker (2008) conducted an experimental study by dividing secondary anatomy and physiology students at a career technology center into experimental (Medical Terminology 350), control (rote memorization), and combination (Medical Terminology 350 and rote memorization) groups while comparing pre- to posttest word recall (Brahler & Walker, 2008). Students in the experimental group (Medical Terminology 350) had significant pre- to posttest word recall improvement compared to the control and combination groups (Brahler & Walker, 2008). It has been suggested that illogical associations can be more advantageous than rote memorization, yet examining its influence in a health science education course is minimal. Visual and keyword mnemonics can easily facilitate illogic representations to aid in terminology preservation.

Incorporating learning tips for medical terminology may improve confidence and produce successful MT retention. Understanding how MT words are broken down, knowing the students preferred learning style, verbal practicing of the word, recognition of word patterns, and writing a list of the terms are all useful tips for learning MT (Neville & Migley, 2008). Vocabulary acquisition preferences and tips may vary among students, but catering to how students learn best may offer teachers the most beneficial instructional tactics.

Vocabulary Acquisition

Students' motivation and performance on assessments may be threatened if they do not understand the vocabulary of their discipline along with its specialized meaning (Rusanganwa, 2013). It is imperative to understand student weaknesses in sound structure storage of mental representations and how support of existing representations in the processing of new words may hinder the foundation of language acquisition (Gathercole, 2006). A sound structure and storage

of mental representation weakness may negate the functionality of vocabulary strategies like mnemonics and ultimately compromise learning. Anatomical structural changes such as local gray and white matter density transpire when learning new vocabulary (Lee et al., 2007). Lee et al. (2007) used brain imagining, behavioral analysis, and white matter tractography to find if gray matter density is related to vocabulary knowledge among monolingual adolescents. The posterior supramarginal gyri area where the grey matter was observed was found to have direct connections to inferior parietal areas where vocabulary is processed (Lee et al., 2007). Increased activity in the left inferior parietal area of the brain was also found during testing practice in which the students saw the word and had to retrieve from memory the translation (Van den Broek, Takashima, Segers, Fernández, & Verhoeven, 2013). From childhood to adulthood, neurophysiological structural changes are observed during the combination of the phonological and sematic properties of words to assist in long-term retention.

Socialization through cooperative learning may produce cognitive and social benefits that aid in MT retention. Iwai (2014) found no statistically significant difference between students who learn vocabulary in cooperative structure groups using cooperative activities and students using more traditional and teacher-fronted approaches. Students perceive a cooperative learning environment as creating a favorable social and affective environment for learning (Iwai, 2014). Advantageously, MT taught in a cooperative environment is implied to create a socially contributory learning environment. The collaboration between visual mnemonics and cooperative learning may conjoin CLT with the social cognitive theory to further benefit student learning. This theoretical collaboration may promote student cognitive and social security and confidence.

Student Perception in Vocabulary Learning

The prominent role that self-efficacy plays in students' academic achievement necessitates a scrutiny of factors influencing student perception (Noroozi & Mehrdad, 2016). Student perception of vocabulary learning strategies is directly related to self-efficacy. Students with high value regarding their academic potential are likely to use rehearsal or elaboration strategy (Wu, Lowyck, Sercu, & Elen, 2012). Students who are confident about learning tend to participate more, work harder, endure through difficulties, and gain higher levels of information (Noroozi & Mehrdad, 2016). Participation in vocabulary learning may be united with peer learning to create a cooperative learning environment. Peer interaction may enhance student self-efficacy and thereby assist in the development of language skills (Noroozi & Mehrdad, 2016). Learning task complexity does not have a significant effect on students' task self-efficacy, learning self-efficacy, and task performance (Wu, Lowyck, Sercu, & Elen, 2013). Students who performed well on previous learning tasks are likely to gain higher self-efficacy thus gaining confidence when learning vocabulary (Wu et al., 2012), suggesting that a simplistic learning task may increase student confidence and learning achievement.

Students who feel that they are wasting their time with unskilled learning tasks may undergo a negative experience which disturbs their confidence to persist in the healthcare profession. When students endure frustration, their personal learning environment may be encumbered from an effective learning progression. Having knowledge of the origins of student frustration may allow educational constituents to focus on decreasing frustration to increase learning. Self-efficacy was found to have a significant relationship with score improvement in medical English terms (Wang et al., 2016). Self-efficacy is related to student confidence and learning achievement.

Vocabulary Strategies

Many students do not develop mastery of vocabulary learning repertoire (Atay & Ozbulgan, 2007). Students may gain proficiency in vocabulary learning strategies if a wide array of strategies is employed. Vocabulary strategies are currently evolving from a predominately teaching-centered tactic to student-centered. Both rote-memorization and the keyword mnemonic method may actuate students' active role in the vocabulary learning process. Atay and Ozbulgan (2007) investigated the effects of memory strategy instruction converged with contextual learning compared to a control group of contextual learning alone. Army aviation pilots who received memory strategy instruction incorporated it into daily learning of air traffic terminology significantly outperformed the pilots who learned only through contextual learning. Atay and Ozbulgan's study indicated the potential of effectual learning when students have strategic options for vocabulary learning and have fall back options. Strategies to advance vocabulary and retention also include modes of practice.

Nosidlak (2013) questioned students at a Polish university to find out what vocabulary learning strategies were used by advanced students. Advanced students were defined as students studying to become English teachers. Advanced students used diverse and multiple sources of new words with an average of six vocabulary sources (Nosidlak, 2013). When advanced learners are provided with multiple sources of MT vocabulary, learning benefits may ensue. In addition to learning sources, the method in which students study newly acquired knowledge may provide educational importance. Repetition and retrieval practices attempt to improve vocabulary retention through specific practice tactics. In parallel importance, the mode of practicing the newly learned word is comparative to the mode of learning that word. Kang, Gollan, and Pashler (2013) contrasted the effectiveness of practicing through imitation versus retrieval practice and

found that retrieval practice produced better comprehension, production of the word, and pronunciation. The imitation method presents pictures and names so students can imitate or repeat each term, whereas students attempt to produce the word prior to hearing it in the retrieval practice condition (Kang et al., 2013). It can be inferred that regardless of the vocabulary instructional mode, when students implement retrieval practice they may have superior vocabulary success. Students were found to believe that having a good structured review is more beneficial than rote memorization (Rashidi & Omid, 2011).

Physiological principles may produce a catalytic of impeding effect on learning and memory (O'Reilly & Rudy, 2000). Specifically, the neocortex employs a slow learning rate compared to the hippocampus which learns rapidly (O'Reilly & Rudy, 2000). The hippocampus uses repeated representations to encode specific events (O'Reilly & Rudy, 2000). A functional magnetic resonance image revealed neocortical regions are involved in memory and the hippocampus predicts associated memory (Hales & Brewer, 2010). Neurobiological studies reveal bidirectional connections between the neocortex and the hippocampus to work together to create representations from previous learning (Eichenbaum, 2000). Neocortical areas enable perceptual, motor, and cognitive information to be processed (Eichenbaum, 2000). The hippocampus sequences learning by linking memories together through commonalities (Eichenbaum, 2000). Together, physiological principles allow the neocortex and the hippocampus to retrieve, link, and compose learning (Eichenbaum, 2000; Hales & Brewer, 2010; O'Reilly & Rudy, 2000).

Similar to retrieval, which derives from producing the word from memory, is the testing effect in vocabulary learning. The testing effect improves long-term vocabulary retention compared to restudying the word by seeing the word and the translation (Van den Broek et al.,

2013). The testing method requires the student to retrieve the translation of the vocabulary term from memory when they see the word (Van den Broek et al., 2013). Twenty-six young adults preformed significantly better on a final memory test through the testing effect comparted to restudying the words (Van den Broek et al., 2013). It is suggested that when reviewing vocabulary, it would best benefit students if they have to retrieve the translation of the word from memory. Index cards could achieve the testing effect by having students write the word on the front and the translation on the back, which is out of sight. Whether or not students are found to learn better through rote memorization or keyword mnemonics, there is noted learning value when a teacher instructs through various learning tactics.

Mnemonics

Variants of mnemonics include acronyms, acrostics, method of loci, pegword method, keyword method, and sematic-based techniques (McCabe, Osha, Roche, & Susser, 2013). Students tend to be more familiar with some mnemonic methods compared to others, and the most common sources of mnemonics in education are those created by the student or provided by the teacher (McCabe et al., 2013). Literature often attributes strong mnemonic potency to the cognitive processing of learning and retaining words with variation in the use of sematic and nonsematic questioning (Bird, 2011). Sematic-conceptual processing can strengthen mnemonics by developing cognitive processing (Bird, 2011). Keyword mnemonics often incorporate illogical associations which derive from non-sematic conceptual processing and shallow processing. Learning through conceptual relations was found more effective than the keyword method and rote memorization (Bird, 2011). However, the keyword method was found more beneficial for beginner learners compared to conceptual relations. Secondary health science

students may be considered beginner learners of MT due to the initial curricular exposure to medical terminology.

Students also attribute reduced subject anxiety and increased motivation and fun with the use of mnemonics while wanting more instructors to utilize mnemonics (Stalder & Olson, 2011). Nursing students gave positive feedback concerning alphabetical mnemonics in constructing nursing care plans (Hussein & Jakubec, 2014). Health science students utilizing mnemonic instruction in high school may be better prepared for a future of potential postsecondary and professional mnemonic learning. Determining an effective mnemonic for educational use necessitates an educator to be malleable in mnemonic variations.

Mnemonic devices have commonly been used in nursing education (Hussein & Jakubec, 2014). Specifically, alphabetical mnemonics strategy has been utilized to create nursing care plans for patients with intracranial pressure, hepatic failure, and chronic renal failure (Hussein & Jakubec, 2014). The alphabetical mnemonic teaching strategy was found favorable in evaluations completed by nursing students (Hussein & Jakubec, 2014). The familiarity of alphabetical mnemonics in nursing may transcend the use of the keyword method to learn terminology in industry.

Healthcare practices require vocabulary that is often considered a secondary language due to its complexity (Badasch & Chesebro, 2011). An examination of best vocabulary practices of a second language may have strategic implications for MT instruction. Purposeful MT instruction should be well founded to encourage health science students' involvement and excitement with vocabulary learning. A considerable amount of research has been conducted concerning vocabulary memorization strategies that have emphasized the connection between association and recall (Yang & Dai, 2012). Excitement in learning may emerge from the

creation of unique vocabulary learning experiences. Songs for mnemonic vocabulary learning helped students retain key information better, added variety to the learning environment, lowered students' stress levels, increased student engagement, and addressed various learning styles (Isabel, 2015). Staggeringly, 19% of students stated that they would not practice singing and 16% responded that the particular songs did not appeal to them (Isabel, 2015). The use of songs as a mnemonic strategy in MT may not be beneficial due to student diversity in music choice and reduced time spent rehearsing. Role play is an additional unique learning strategy that may be utilized in MT. Role play produced significantly higher posttest mean scores of students who were taught English through role play compared to students taught by traditional methods (Alabsi, 2016).

Mnemonics often foster active learning that addresses multiple modes of learning that are engaging, competitive, and interesting. Through the use of word-matching games to learning MT, students expressed a new-found excitement towards anticipation of class time (Nuetzman & Abdullaev, 2012). Student motivation to attend class may produce significant implications throughout their educational and career endeavors. Students who learned MT through word-matching games were able to translate medical terms, differentiate confusing terms, perform under time pressure, and works as a team among their classmates (Nuetzman & Abdullaev, 2012). Commissioning unique methods that stray from traditional modes of medical terminology instruction is likely to peak student interest. Vocabulary learning can transform a classroom into a fun and engaging academic environment. The use of storytelling can change a boring learning environment into an exciting place made of student engagement and production (Kalantari & Hashemian, 2016). Medical Terminology 350 utilizes the keyword mnemonic method similar to the story telling approach. It is necessary to dichotomize vocabulary learning

strategies that are employed by educators to draw a parallel on student achievement with vocabulary retention.

There is a positive relationship between CTE courses taken in high school and post-high school career placement among students with disabilities (Wagner, Newman, & Javitz, 2015). Cognitive needs of adolescents with learning disabilities should not be overlooked concerning audio and visual instructional strategies (Kennedy et al., 2013). Instructional strategies should be developed and enacted from evidence-based practices. Mnemonics are based on evidence-based practices from a multitude of research.

Vocabulary was taught to a large group of secondary general education students and students with learning disabilities (LD) using content acquisition podcasts (Kennedy et al., 2013). Students with LD significantly outperformed students with learning disabilities who were not taught using a theoretical framework basis for the multimedia instruction (Kennedy et al., 2013). The use of multimedia in vocabulary instruction needs to be theoretically framed for an intentional instructional design. Significant vocabulary knowledge results mirrored general education students and students with LD (Kennedy et al., 2013). The keyword mnemonic method is theoretically based on the CLT and synthesis of Kennedy et al. (2013) findings suggests use of multimedia to deliver the keyword mnemonics method is effective when the multimedia method is purposefully designed.

Picmonic learning is a mnemonic variation that contributes to vocabulary retention. Picmonic learning has been found to improve memory retention among medical science students (Goel et al., 2014). Students in a picmonic learning group demonstrated significant recall improvements of disease topics compared to students who learned through text-based materials (Goel et al., 2014). The picmonic card learning strategy is similar to the keyword method in that

a picture associates a link to a term and association. The picmonic card is a linear narrative that connects characters together as a story (Goel et al., 2014). The picmonic card method proposes that students retain terminology from building a picture association to a term without the focus of an audionym such as the keyword mnemonic method.

Mnemonics can often assume a multimodal strategy integrating contributing learning strategies. The Production Effect (PE) is a mnemonic and memorization strategy that derives when the learner studies aloud (Icht & Mama, 2015). Icht and Mama (2015) tested the memorization in a PE paradigm using pictures as stimuli with a group of 5-year-old children. There was a noted memory advantage for vocally produced words ("look and say") compared to ("look, look, and listen"; Icht & Mama, 2015). The keyword method may be instructionally designed for vocal practice of new vocabulary words. While the PE method is shown as an effective memorization strategy in young children and adults, there is no evidence of its effectiveness among high school-aged learners. Reading aloud may consequentially distract secondary learners. Though a design principle to managing cognitive load is through the learner speaking the word (Kang et al., 2013; Van Merriënboer & Sweller, 2010), there is still little evidence on the effects of learning in a spoken-aloud group setting.

Keyword Mnemonic Method

The keyword mnemonic method, keyword method, and visual mnemonic are descriptions used interchangeably. The keyword method was created by Atkinson in 1975 and is a common method consisting of a two-step approach, used primarily for learning a foreign language (Siriganjanavong, 2013). The learner first makes an acoustic link between a familiar and unfamiliar word, as a sound-alike (Brahler & Walker, 2008; Siriganjanavong, 2013). The learner will then create an imagery link between the familiar and unfamiliar word (Brahler & Walker,

2008; Siriganjanavong, 2013). The creation and use of associations either structurally or semantically help students to retain more words for a longer period of time (Yang & Dai, 2012). Educators should strive to employ medical terminology strategies that deepen cognitive processing. Deeper vocabulary processing results in improved temporary retention which may permanently establish memory representations for the newly learned word (Sagarra & Alba, 2006). The keyword method is often a popular learning preference among students. A group of psychology students rated keyword mnemonics as more familiar, used, and most helpful (McCabe, Osha, Roche, & Susser, 2013). In both psychology and health science, there is a wide array of learning styles and preferences, suggesting that health science students may also prefer keyword mnemonics. Keyword mnemonics has also been found to reduce problems in the retention of vocabulary (Davoudi & Yousefi, 2016), and result in better recall both in short-term and long-term memory (Siriganjanavong, 2013). A significant increase in students' retention with the use of keyword mnemonics may be attributed to supporting factors such as rehearsal, pictures to demonstrate the keyword, use of nouns with high imagery value and phonemic overlapping (Dolean, 2014). The type of instructional strategy employed often affects short- and long-term memory.

Keyword mnemonics have been found operational for storing and recalling information while supporting a pre-comprehension strategy in fully interpreting and knowing the word (McCarville, 1993). Keyword mnemonics contribute to knowing the surface meaning of a word with a catalytic reaction in the recognition of the word (McCarville, 1993). An introduction to medical terminology through keyword mnemonics may continue to strengthen student comprehension and fluency when later encountered in the health care profession.

Mixed results concerning the keyword method and vocabulary recall suggest that the use of various experimental procedures and testing protocols may facilitate findings of longer term retention and a decline in retention (Wyra, Lawson, Hungi, 2007). Wyra et al. (2007) sought to further investigate two internal components of the keyword method on forward and backward recall among a group of 11–12-year-old foreign language learners. The two internal components examined included explicit training in the use of the keyword method and students, and self-rated ability to use an image. Training in the use of the keyword method at the time of retrieval was not educationally significant but should be incorporated prior to use (Wyra et al., 2007). Student rating for the ability to make images made a small but significant impact (Wyra et al., 2007), indicating it is beneficial for students to be properly training in the keyword method along with conceptualizing the importance of imagery.

The instructional strategy utilizing the keyword mnemonic method should be intentional and persistent in achieving prosperous scholastic results. Mnemonics that are meaningful to the learner tend to result in successful retention (McCabe, 2015). Learner-generated mnemonics may originate from a personal meaning from the learner, but may not be instructionally realistic in a secondary classroom. A group of first-year college students enrolled in an introductory psychology class participated in learner-generated keyword mnemonics, instructor-provided mnemonics, and real-life examples (McCabe, 2015). Neurophysiology is a specialty area of healthcare and is common among professionals in the field of psychology and healthcare. Students who learned neurophysiology terminology by the keyword-generated strategy produced superior quiz results compared to learning through real-life examples and instructor-provided mnemonics (McCabe, 2015). The evidence that students retain terminology better when they generate the mnemonic may encourage instructors of MT to create a learner-center approach

when employing the keyword mnemonic method. Neurophysiology is one of the many specialty areas of the medical field that is formed by problematic terminology. Challenging medical terminology may be best learned through the assistance of content scaffolding.

Undergraduate students who learned the Krebs Cycle through a picmonic system retained more knowledge than those who used rote memorization (Hussein & Jakubec, 2014). The high degree of difficulty in learning the Krebs Cycle combined with its integration into exercise physiology and kinesiology parallels its findings with a health science curriculum. Though research has suggested that mnemonics are more effective compared to rote memorization, educators continue to engage rote memorization in vocabulary.

Educators should take into consideration students' learning styles and learning preferences for acquiring new information (Siriganjanavong, 2013). Findings suggest students prefer to engage in vocabulary learning strategies that would be most appealing to them with less manipulation of the language (Yang & Dai, 2012). Knowledge of students' preferred method of learning MT may allow a health science teacher to maintain student interest while yielding proficient retention outcomes. Of four vocabulary memorizing strategies (rote repetition, structural associations, sematic strategies, and mnemonic keyword), postsecondary students found structural association and sematic strategies most employable (Yang & Dai, 2012). Taking notes of vocabulary items in the margins of a textbook was favorable by postsecondary students (Yang & Dai, 2012), which may be replicated by students writing an element and association meaning on an index card.

Learning vocabulary words by associational patterns has gradually replaced most rote learning with most students having unfavorable views of conventional rote learning methods (Yang & Dai, 2012). Keyword mnemonics has been proven effective while unpopular among

some language learners (Yang & Dai, 2012). The unpopularity of keyword mnemonics may be due to unfamiliarity with the active use of a language (Yang & Dai, 2012). Acknowledging the progressive use of association to lead vocabulary combined with the unfavorable view of rote memorization implies the effective nature of keyword mnemonics to teach medical terminology. Increased use of keyword mnemonics may engage familiarity while potentially adhering to student learning preference.

Vocabulary Retention System

There are learning programs that strive to simplify MT due to its communicative necessity among healthcare professionals and complexities in term technicalities. According to a book review (Gelsomino, 2006), one program approach uses a word-building method while engaging the students to complete activities in a workbook. Most vocabulary retention systems are derived from student engagement from a learning stimulus. The Dean Vaughn Medical Terminology 350 Total Retention System, also known as Medical Terminology 350, facilitates the recall of factual information by linking information to existing knowledge (Brahler & Walker, 2008). The new information is linked to a learner's previous knowledge through the building of an association. A sound-alike keyword (audionym) and related familiar picture are presented to the learner to create an association to a Greek or Latin scientific word part (element; Brahler & Walker, 2008). Language learning tasks have an effect on students' learning and pedagogical formation (Sarani, Behtash, & Arani, 2014). Learning tasks may be strategically centered on learning objectives to promote academic enrichment. Vocabulary learning though the keyword mnemonic method requires listening comprehension of the presented audionym (Siriganjanavong, 2013). Listening comprehension and understanding terminology is more effective when listening to video-based learning tasks (Sarani et al., 2014). Subtitles have also

been found effective in learning vocabulary development (Sirmandi & Sardareh 2016). Participants viewed video clips to determine the effect of subtitles on vocabulary retention and concluded that the use of subtitles yields greater vocabulary retention (Sirmandi & Sardareh 2016). Medical Terminology 350 presents the picture along with subtitle of the medical term and audionym.

Illogical associations may enable learning to maintain interest and promote effectual long-term retention. The keyword mnemonic method is one of the most extensively researched mnemonics in teaching new vocabulary, yet few teachers report using keyword mnemonics in part due to the difficulty of creating the keywords (Dolean, 2014). Medical Terminology 350 gives all needed information to teach MT using the keyword mnemonic method, reducing teacher time spent creating keywords. The links presented in Medical Terminology 350 are direct and purposeful. First language keywords should be phonologically similar to the language instead of multiple links which may weaken the association (Sagarra & Alba, 2006). A weakened association will diminish the anticipated outcome of utilizing the keyword mnemonic method. Concurrently, a weakened association may unintentionally transform into rote memorization due the complexity of the multiple links.

Visual perception and presentation may stimulate student learning through the use of multimedia instructional strategies. Kim and Kim (2010) investigated the effect of screen size when multimedia instruction is used, specifically examining the use of text only and text accompanied with a picture. There was little difference found between the type of multimedia instruction, but it was determined that a larger screen size is more effective when using multimedia. Classrooms with large display boards or screens may naturally enhance vocabulary learning through multimedia. Educational technology may be transient when previous

information disappears and is replaced by current information, and as such technology that transforms information needs to be examined (Wong, Leahy, Marcus, & Sweller, 2012). Wong et al. (2012) investigated the effects of transience from animation-based instructions and under audio-visual conditions. Both means of presentation introduced transience that may impose an impeding cognitive load which inadvertently is consequential to learning. Cognitive load is higher with increased video segment length (Wong et al., 2012), providing support for the need of decreased video segment length when learning vocabulary.

Rote Memorization

No Child Left Behind (NCLB) has created a learning environment that focuses on assessment success instead of a personalized learning experience (Jones, 2012). A lower-order pedagogy such as memorization of MT may provide foundational knowledge necessary for critical thinking and problem solving (Brahler & Walker, 2008). Memorization is a cognitive strategy that focuses on the storage and retrieval of language and is referred to as rote memorization (Nasrollahi-Mouziraji & Nasrollahi-Mouziraji, 2015). Rote memorization is a traditional approach to vocabulary learning and is the primary preference of teachers due to NCLB (Jones, 2012). Rote memorization involves limited student engagement in learning (Fata-Hartley, 2011). A questionnaire yielded that learners believe rote memorization is an effective method of learning vocabulary but not the best method (Rashidi & Omid, 2011). When learning speaking skills, students prefer to learn through engaging activities compared to rote memorization (Che Haron, 2012). MT is a language that requires healthcare professionals to employ learned speaking skills in everyday work.

Saricoban and Basibek (2012) compared the effects of the keyword mnemonic and context method on 20 target words comparing immediate recall, recognition, and delayed recall.

There was a significant improvement in the recall and recognition among the groups using the keyword mnemonic method (Saricoban & Basibek, 2012). These findings suggest that students learn vocabulary better though keyword mnemonics instead of methods similar to rote memorization in producing immediate and long-term understanding and recognition benefits.

Rote memorization may be the preferred terminology learning strategy of some students, so educators should be aware of the implications. Increased use of rote memorization and critical thinking among foreign language students revealed decreased test anxiety, with critical thinking more influential in decreased anxiety (Aldhafri, Alkharusi, & Ismaili, 2015). Critical thinking is a necessity for healthcare professionals' job skills and responsibilities. Rote memorization does not fully engage, motivate, and encourage active student participation, but due to professional constraints is often favored by teachers (Jones, 2012). In nursing, mnemonics may simulate flowcharts or checklists to assist complicated clinical decision-making processes (Bruno, Ip, Shah, & Linn, 2012). The combination of visual mnemonics with critical thinking may decrease test anxiety while simulating industry expectations. Inversely, the traditional approach of rote memorization is not found to produce profound vocabulary retention. Two important educational goals are to promote retention (occurs through rote learning) and to promote transfer (indicates meaningful learning; Mayer, 2002). The traditional focus of rote learning is remembering fragments of knowledge compared to meaningful learning strategies which constructs new knowledge (Mayer, 2002). Rote learning becomes a means to an end rather than the end itself (Mayer, 2002).

Summary

The importance of MT retention in meeting professional prerequisites in the medical field is evident throughout the literature (Wang et al., 2016). Knowledge of word elements and

differentiation of prefixes, roots, and suffixes will ease a student into the specialized and communitive language of the medical field (Badasch & Chesebro, 2011). However, a review of literature revealed very little useful research on the validity and reliability of instruments to effectively assess best teaching and learning practices.

The vocabulary instructional strategy elected to teach MT should be diversified to address student learning styles (Threeton & Walker, 2009), while trying to decrease an overbearing cognitive load (Qiao et al., 2014). Research has shown that the keyword mnemonic method is a popular learning preference among students (McCabe, Osha, Roche, & Susser 2013) and may result in better short- and long-term vocabulary retention (Siriganjanavong, 2013). Though the keyword mnemonic method is a commonly researched mnemonic (Dolean, 2014), rote memorization as a current learning method remains a primary preference of teachers (Jones, 2012).

A gap in the literature was found when no study determined the psychometric properties of the MT350, an assessment used to measure students' MT recall. A need still endures to fill research gaps between MT assessment measures.

CHAPTER THREE: METHODS

Overview

There are a lack of psychometric studies to examine the Medical Terminology 350 Final Test (MT350). Without a valid and reliable assessment tool, conclusive studies on the topic of student retention of medical terminology education are not possible.

It is necessary to examine the psychometric properties of a commonly used medical terminology assessment by examining the assessment instrument's validity and reliability. This chapter describes the research design, participants, setting, instrumentation, procedures, and data analysis to test the hypothesis that MT350 is a valid and reliable instrument to assess medical terminology recall.

Design

This purpose of this study was to evaluate the psychometric properties of the MT350 to include descriptive statistics, reliability, and validity. Specifically, content validity and internal consistency were evaluated. Ten content experts reviewed the MT350 to determine content validity. A convenience sample of MT350 archival data scores were used. Psychometric evaluation of reliability and validity included individual item analysis for content validity and KR20 for internal consistency. The psychometric analysis of the MT350 was completed in two evaluations.

Content Validity

Content validity describes the extent to which the assessment correctly operationalizes the concepts being studied (Gall, Gall, & Borg, 2015). A panel of 10 content experts determined the degree to which the MT350 is a valid instrument by using Lawshe's (1975) content validity ratio (CVR). Lawshe's (1975) CVR is one of the easiest and most common methods to quantify

content validity (Ayre & Scally, 2014; Wilson, Pan, & Schumsky, 2012). The CVR has been widely used to determine content validity in diverse fields including healthcare and education (Wilson et al., 2012). Further details on CVR analysis are described in Chapter 3 under the section titled "Data Analysis."

Internal Consistency

Reliability is the extent to which a test yields the same result on repeated measures (CoPo, 2015). The Kuder-Richardson formula (KR) is a commonly used rational equivalence formula that yields a reliability coefficient (Gall et al., 2007). The KR20 formula is commonly used to determine reliability of vocabulary assessments (Qi & Marley, 2010; Suwantarathip & Orawiwatnakul, 2015; Townsend, Bear, Templeton, & Burton, 2016). The KR20 is appropriate when a test instrument is dichotomously scored (right/wrong) and aggregated to produce a composite score, such as the MT350 (Gall et al., 2007).

Research Questions

RQ1: Is the MT350 a valid instrument to assess medical terminology retention learned by the keyword mnemonic method among secondary health science students?

RQ3: Is the MT350 a reliable instrument to assess medical terminology retention learned by the keyword mnemonic method among secondary health science students?

Hypotheses

The following were the research hypotheses:

H1: The MT350 instrument has an acceptable validity score greater than or equal to 0.62 as noted on CVI for assessing medical terminology retention among secondary health science students.

H2: The MT350 instrument has an acceptable reliability score greater than or equal to 0.70 for measuring medical terminology retention among secondary health science students. Alternatively, the following were the null hypotheses:

$H_0$1: The MT350 instrument does not have an acceptable validity score greater than or equal to 0.62 as noted on CVI for assessing medical terminology retention among secondary health science students.

$H_0$2: The MT350 instrument does not have acceptable reliability score greater than or equal to 0.70 for measuring medical terminology retention among secondary health science students.

Participants and Setting

There were two distinctive groups of participants in this research study. In order to analyze item consistency, participant archival MT350 data were used. To analyze content validity, a participant group of 10 content experts evaluated the MT350.

Content Validity

The participants for content validation of the MT350 consisted of 10 experts in the fields of health and education. Participants were purposefully selected from the secondary and postsecondary setting with a background in health, experience in education, a minimum of a Master's degree, and spoke English as a primary language. This criterion was determined through email between the researcher and participants. Professional colleagues of the researcher were invited to participate via email (see Appendix D). Additionally, participants were asked if they could recommend any colleagues interested in participating in this study. This professional referral approach created a snowball sampling to widen participation. The sampling of content

expert participants was convenient, purposeful, and comprised of various expertise within health and education.

Reliability

Participants in this study consisted of archival data. A convenience sample of approximately 102 students in a secondary health careers education program who are enrolled in a health careers related course in the state of Tennessee and Missouri were recruited. Student expression of interest in pursuing a career in the medical field is a prerequisite for enrollment in the health careers education program. A priori testing to determine sample size for .80 power was done using G*Power 3 analysis (Faul, Erdfelder, Lang, & Buchner, 2007). The analysis was conducted using a medium effect size of .08, and results indicated 102 subjects would provide a power of .80.

Archival data were originally collected from two secondary public schools throughout the states of Tennessee and Missouri. Health Careers Certification programs prepare students for a career in health care with the opportunity to obtain multiple health care certifications ("Health Careers Certification," n.d.). The archival data originated from two secondary schools located at a career center ("School 1") and a traditional high school ("School 2"). The health-related occupations course at the career center is designed to teach students beginning skills and basic procedures needed for an entry level job. The health science program at the career center is designed for students in 11th to 12th grade, whereas the traditional high school course is designed for students in 10th to 12th grade.

Most of the health science educators teach a core of health science courses and then at least one health profession course such as long-term care nurse aide, etc. Depending on the rural or urban area the school is in and what other programs are offered in their area, many of the

Health Careers Educations programs have both high school and adult programs. Student grade level ranged from ninth grade to 12th grade. Students completed the 350-question posttest during regular scheduled class time in the health career education classroom.

Instrumentation

The Medical Terminology 350 Final Test (MT350) was the instrument analyzed in this study. The MT350 was developed by the Dean Vaughn Total Retention System as a final assessment to determine participants' medical terminology recall, with a total of 350 questions. With over 35 years of research, development, and testing, the Dean Vaugh Total Retention System is currently used throughout the world in academic, health, and business institutions (Vaughn & DCM Instructional Systems, 2006). The Dean Vaughn Total Retention System offers courses in SAT vocabulary, anatomy, dental education, Spanish, books of the Bible, periodic table, etc. ("The Dean Vaughn Retentions System," n.d.). This study was specifically interested in the assessment associated with the Medical Terminology course. The MT350 is a 350-question assessment that requires the student to print the meaning of each element. A space is also provided for the participant to include the audionym as an aid to recall the meaning (Vaughn & DCM Instructional Systems, 2006). Participants are only scored on the meanings of the elements (Vaughn & DCM Instructional Systems, 2006).

Vaughn and DCM Instructional Systems (2006) suggest the following instructional tactics to achieve 100% on the MT350:

> Participate with the audiovisual presentation, pronounce the terms aloud during the presentation, complete the lesson review exercise while reviewing each element and picture in your mind, complete the worksheet exercise after reviewing each lesson, and complete the final review of all 350 elements after the completion of all fourteen lessons.

Always, pronounce the element, think of the audionym, picture the illogical association, and recall the meaning.

The MT350 has not been used in previous studies to examine reliability, validity, and appropriateness. The construct psychometric properties of MT350 were determined using a secondary analysis with IRB approval.

Validity

The researcher created a 350-question survey based on the 350 test items on the MT350 (see Appendix E). A content expert panel evaluated each of the 350 items found on the MT350. The researcher used the current MT350 and added a column for panel members to rate each test item on a 3-point Likert-type scale for item essentiality. A panel of 10 content experts rated each item on the MT350 on a 3-point Likert-type scale (3 = essential, 2 = useful, but not essential, 1 = not necessary) based on Lawshe's (1975) item-analysis method. The panel members left commentary to assist in improving validity.

Procedures

Validity

Upon IRB approval, the researcher purposely recruited content experts (CE) from a population of diverse health science colleagues, faculty, and curriculum leaders. The targeted CE panel members had practice in health, experience in education, a minimum of a Master's degree, and spoke English as a primary language. The CE panel should be composed of experts about the domain being studied, preferably from a range of professional levels (Gilbert & Prion, 2016). Following determination of the CE panel members, their quantitative and qualitative viewpoints on the representativeness of content was analyzed. As noted in previous studies (Bravo et al., 2016; Carter et al., 2016; Kara & Celikler; Wu et al., 2016), content experts are

commonly used in the development and revision of a test instrument. The CE panel was asked to evaluate the content validity of the MT350 using Lawshe's (1975) 3-point Likert scale on essentiality. In addition to rating each item, experts provided constructive comments. Ten content experts participated in the review. A review panel of two to 20 experts was recommended (Carter et al., 2016) with five to 10 preferred (Gilbert & Prion, 2016).

Content experts were selected from the secondary and postsecondary setting, had a background in health, experience in education, minimum of a Master's degree, and spoke English as a primary language, all of which would represent other experts in a similar working environment. CE panel members were emailed a request for participation (see Appendix D) and consent form (see Appendix E). CE panel members' consent was evidenced by a signature. Each CE panel member was emailed the MT350 and a self-developed evaluation Validation Instrument for Content Expert Review (see Appendix F). The Validation Instrument for Content Expert Review was emailed as a Microsoft Word document for the CE panel members to rate and email back to the researcher. The participants' demographics were collected in an email and are reported in Table 1.

Table 1

Demographics of Content Expert Panel

Reviewer	Degree	Setting	Primary Language	Academic Profession	Medical Background
CE01-Female	D.H.S	Postsecondary	English	Faculty	Athletic Trainer
CE02-Female	M.A.	Secondary	English	Health Science Teacher	Surgical Technologist
CE03-Female	Ed.S	Secondary	English	Health Science Teacher	Registered Nurse
CE04-Female	M.S.N	Secondary	English	Health Science Teacher	Registered Nurse
CE05-Female	Ed.S	Postsecondary	English	Faculty	Athletic Trainer
CE06-Female	M.S.N	Secondary	English	Health Science Teacher	Registered Nurse
CE07-Female	M.S.Ed	Secondary	English	Health Science Teacher	Athletic Trainer
CE08-Male	Ph.D	Postsecondary	English	Faculty	Sports Psychologist
CE09-Female	Ed.D	Postsecondary	English	Faculty	Athletic Trainer
CE10-Female	M.A.	Postsecondary	English	Faculty	Medical Assistant, Cardiology Technologist, Insurance Medical Biller and Coder

Reliability

After approval was granted by the Institutional Review Board (IRB), a permission request form (See Appendix C) and a copyright permission form (See Appendix B) were emailed to The Director of National Accounts for Peterson's Nelnet, LLC. Director of National Accounts

for Peterson's Nelnet, LLC permission was evidenced by a signed statement on official letterhead. Scored MT350 assessments were uploaded and emailed with total scores and individual item scores to the researcher through an encrypted email. Each record included 1) student identification number (anyonmous data), 2) total MT350 score, and 3) individual item score.

Data Analysis

The internal consistency of the MT350 was estimated using a rational equivalence method. The KR20 formula calculated items that are score dichotomously as either correct or incorrect (Gall et al., 2007). The meaning of the medical items on the MT350 was scored as correct (1) or incorrect (0). The KR20 contains measurements between 0.00 and 1.00 (CoPo, 2015). A high KR20 indicates test items are relatively homogeneous, while a low KR20 indicates test items may be loosely related (CoPo, 2015). According to CoPo (2015), "KR20 coefficients below 0.64 are often an indication that the scores should be interpreted with caution" (p. 192).

A panel of content experts (CE) determined the degree to which the MT350 is a valid instrument to measure concepts that are structurally and theoretically related to medical terminology (DeVon et al., 2007). A panel of 10 experts was asked to rate all MT350 items on a 3-point Likert-type scale. The CE rated each item on the MT350 by responding to the following question: Is the medical element measured by this item (3 = essential, 2 = useful, but not essential, 1 = not necessary) to the performance of measuring medical terminology knowledge. Data from the CE ratings were analyzed using Lawshe's (1975) equation to calculate the content validity ratio. The equation, $CVR = (ne - N/2) / (N/2)$, where *ne* is the number of expert panel reviewers indicating "essential," and *N* is the total number of experts was used (Lawshe, 1975).

"Content validity ratio ranges between −1 (perfect disagreement) and +1 (perfect agreement) with CVR values above zero indicating that over half of panel members agree an item essential" (Ayre & Scally, 2014, p. 79).

Individual item content validity was considered acceptable when five out of 10 CE members scored the item as "essential." Individual item content validity was considered acceptable with a CVR score greater than or equal to 0.50. MT350 validity was considered acceptable if the CVI score was greater than or equal to 0.62. The CVR is the individual item statistic, whereas the CVI is the mean of the CVR values.

The mean of the CVR for all items on the MT350 was used to determine the overall test content validity. Changes or new item recommendations made by the CE panel in this study will be presented to the proprietor of the MT350. It will be the proprietor's discretion whether or not to incorporate the recommendations from the CE panel.

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0. Individual scores were summed for total correct meaning definition responses out of a possible 350 points. Items were labeled Q1-Q350, individual items were scored 0=incorrect or 1=correct. Secondary analysis was done on a data set containing 102 MT350 test-takers, identities blinded. Descriptive analysis, means, and standard deviations of the MT350 were calculated. An outlier is defined as a MT350 score that differs markedly from other MT350 scores in the sample (Gall et al., 2007). In the actual research from which these data were drawn, it was independently determined that MT350 data that were less than 50% complete (175 items or less) to be an outlier and removed from the study (Gall et al., 2007). Data analysis for validity and reliability consisted of individual item analysis for content validity and KR20 for internal consistency.

Descriptive statistics organized and summarized the MT350 numerical data (Gall et al., 2007). The mean indicated the average MT350 total score among *N*=102. The median designated the middle point of the distribution of MT350 total score among *N*=102 (Gall et al., 2007). The range revealed the distance between the minimum and maximum MT350 scores by calculating the difference between the highest and lowest value among *N*=102. The variance was calculated by taking the mean of the squared differences between each MT350 score and the mean value of scores. The standard deviation measured the dispersion by determining the square root of the variance. Reliability coefficients vary between .00 and 1.00 with 1.00 indicating perfect reliability and .00 indicating no reliability (Gall et al., 2007). Cronbach's coefficient alpha examined reliability with .70 as the accepted minimum (Laurie & Sloat, 2016; Reeve et al., 2007).

Assumption Testing

Visual analysis was used to screen data for normality. Prior to the psychometric properties being evaluated, violations of assumptions were checked to determine equal distribution of sample MT350 means from School 1 and School 2. Normality was checked using a histogram for a symmetrical, bell-shaped curve. A scatter plot was used to check for presences of extreme outliers, cigar shape, and linearity. The Levene's test for equality of variance was used to determine homogeneity of variance and whether it can be assumed and is tenable. A significance level larger than .05 indicates that equal variances can be assumed, and a level less than .05 indicates that variance cannot be assumed. The effect size was determined using eta squared, the sum of squares between groups divided by the sum of squares (Green & Salkind, 2014). The eta squared value was evaluated for effect size using Cohen's d (1988). The quality of the data was screened to avoid any misinterpretation of

data. Data were checked for missing values and irregular data patterns. Extreme or unusual values were screened to avoid incorrect scores being reported. The outlier value was considered a score that differs markedly from student scores with less than 50% completion (Gall et al., 2007). The missing, irregular, extreme, or unusual values were eliminated (n = 41).

CHAPTER FOUR: FINDINGS

Overview

The purpose of this instrument research was to analyze the validity and reliability of the Medical Terminology 350 Final Test (MT350) in a population of secondary health science students. The study examined the archival data from the Fall 2018 and Spring 2019 secondary MT350 scores of students who participated in Dean Vaughn's Medical Terminology 350 course. The literature to date does not adequately address the issue of best teaching and learning practice for students in health science (Shoemaker & Kelly, 2015). Specifically, there is a lack of psychometric data for the MT350. Without a valid and reliable assessment tool, quantitative studies have not been possible to measure best teaching and learning practices. The research supports the cognitive load theory by being directly related to medical terminology instructional techniques and relevancy in medical education (Young et al., 2014). The methods used to investigate validity and reliability of the MT350 included a content expert panel review and KR20 analysis. The results of this study are discussed in this chapter.

Research Questions

RQ1: Is the MT350 a valid instrument to assess medical terminology retention learned by the keyword mnemonic method among secondary health science students?

RQ2: Is the MT350 a reliable instrument to assess medical terminology retention learned by the keyword mnemonic method among secondary health science students?

Null Hypotheses

$H_0$1: The MT350 instrument does not have an acceptable validity score greater than or equal to 0.62 as noted on CVI for assessing medical terminology retention among secondary health science students.

$H_0$2: The MT350 instrument does not have acceptable reliability score greater than or equal to 0.70 for measuring medical terminology retention among secondary health science students.

Descriptive Statistics

Descriptive statistics were used to draw conclusions on the psychometric properties of the MT350 among a population of secondary health science students. Data were analyzed using statistical software SPSS (25.0) and Microsoft Excel. Descriptive statistics were analyzed for variables including mean, standard deviation, and range. Histograms, Q-Q plot, and simple scatter plots were generated using SPSS. All analyses were tested to a significance level of 0.05. The research questions were addressed using Lawshe's (1975) CVR formula and KR20.

A total of 102 MT350 tests were analyzed. In consideration of outliers, 41 MT350 archival scores were omitted from the original data set due to less than 50% completion. All MT350 data with at least 50% completed (n=102) were included in the sample population. School 1 (n = 47) had no outliers. School 2 (n = 55) had 41 outliers that were omitted. The final MT350 archival data, excluding outliers, included 102 ninth through 12th grade students and four health science teachers across two public high schools. An independent-samples t-test was conducted to determine if there was a statistically significant difference between the means of the MT350 scores for School 1 and School 2.

MT350 total scores were reported as scale scores. Scale scores on the MT350 of the population sampled ranged from 143 to 348 out of a maximum range of 350. This is illustrated in Table 2. See Table 3 for extreme values of MT350 scores.

Table 2

Descriptives of MT350 Scores

			Statistic	Std. Error
MT350_Total_Score	Mean		284.94	6.213
	95% Confidence Interval for Mean	Lower Bound	272.62	
		Upper Bound	297.27	
	5% Trimmed Mean		288.75	
	Median		305.00	
	Variance		3937.620	
	Std. Deviation		62.750	
	Minimum		143	
	Maximum		348	
	Range		205	
	Interquartile Range		108	
	Skewness		-.748	.239
	Kurtosis		-.766	.474

Table 3

Extreme Values of MT350 Scores

			Case Number	Value
MT350_Total_Score	Highest	1	13	348
		2	33	348
		3	36	348
		4	46	348
		5	47	348
	Lowest	1	73	143
		2	85	144
		3	102	155
		4	69	161
		5	81	162

Table 4

Group Statistics for School 1 and School 2

	School	*N*	Mean	Std. Deviation
MT350_Total_Score	1	47	300.83	52.625
	2	55	271.36	67.810

The group descriptive statistics for School 1 and School 2 are shown above in Table 4. The descriptive statistics include *n*-size of the sample population (*N*=102), mean, and standard deviation included in the analysis.

Results

Assumption Tests

To address the research questions, visual analysis was completed to examine normality of MT350 data. Data were assessed for normality, linearity, and homoscedasticity. The following histogram (Figure 1) provided an analysis of normality. Figure 1 contains the frequency distribution of the MT350 total scores of secondary health science students (*N*=102). The data shown is negatively skewed.

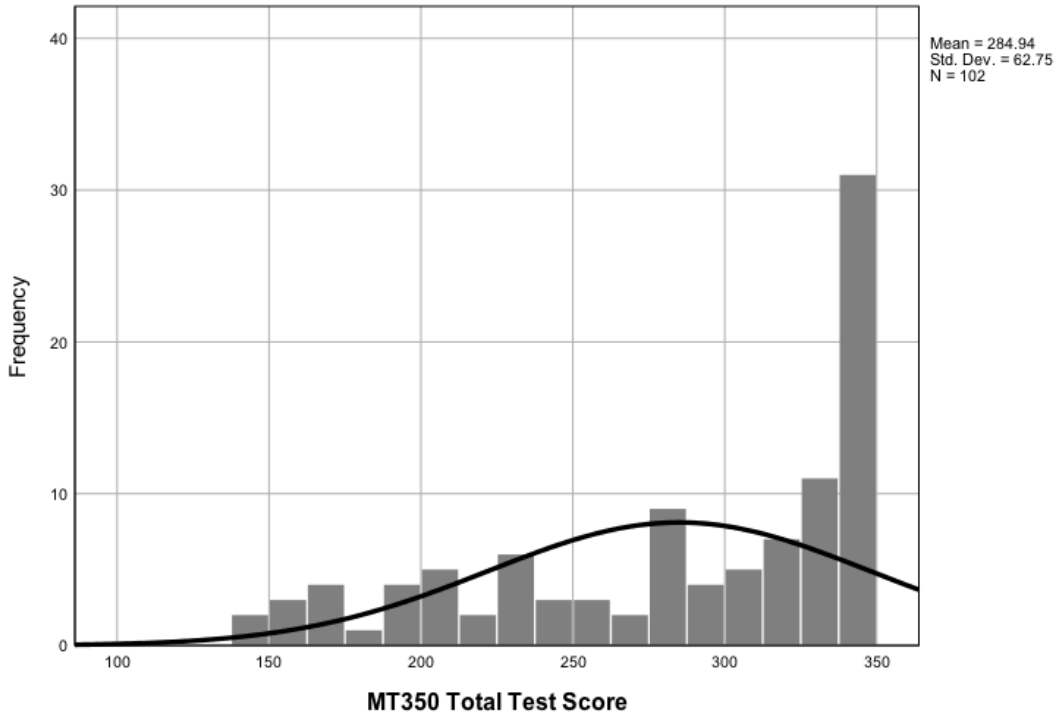

Figure 1. Histogram of MT350 Total Test Score

Visual analysis continued to examine frequency of MT350 total score data using a simple scatter plot with a fit line in Figure 2. Figure 2 does not indicate strength or correlation. Visual analysis indicates homoscedasticity exists with MT350 total scores having approximately the same scatter. Dots are noticeably clustered closely together at or above 300, indicating a majority of total scores falling between 300 to 350.

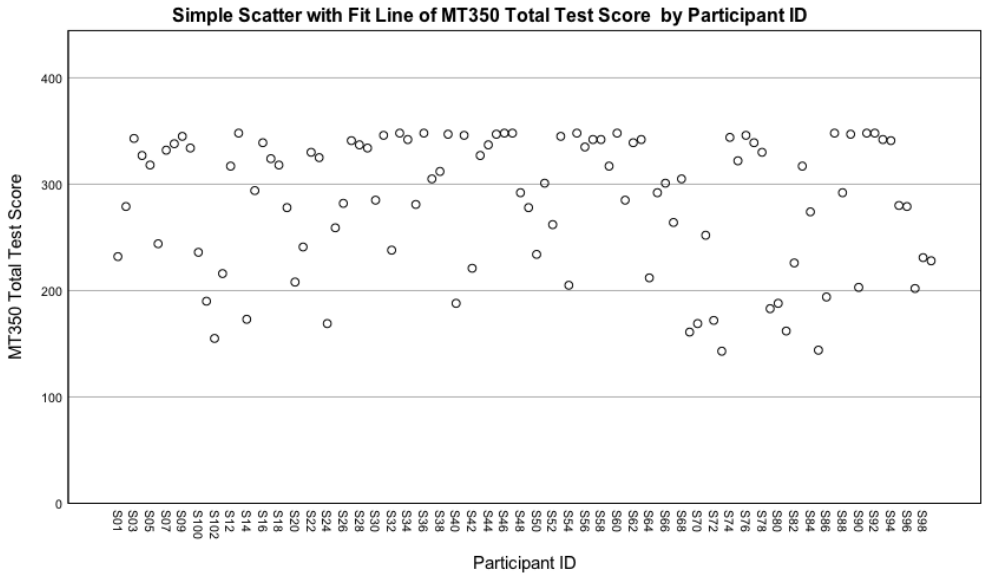

Figure 2. Scatter Plot of MT350 Total Test Score by Participant ID

To compare the distribution of the MT350 data for the 102 secondary health science participants, Q-Q plots were used. Based upon a visual assessment of the Q-Q plots, the MT350 scores were approximately normally distributed, indicating normality has been met to conduct an independent-samples *t*-test. Figure 3 shows the Q-Q plot for School 1 group. Figure 4 shows the Q-Q plot for School 2 group.

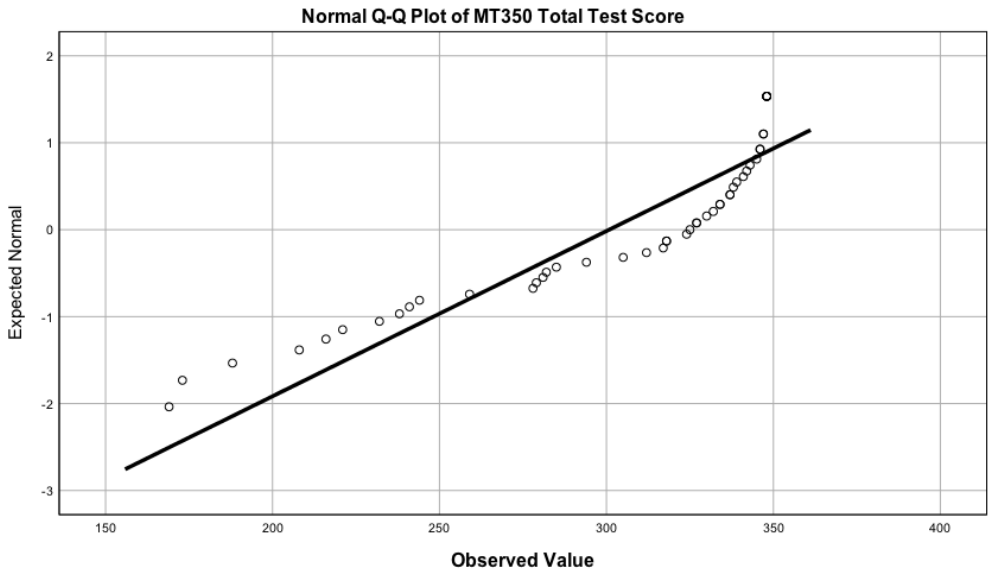

Figure 3. School 1 Q-Q Plot

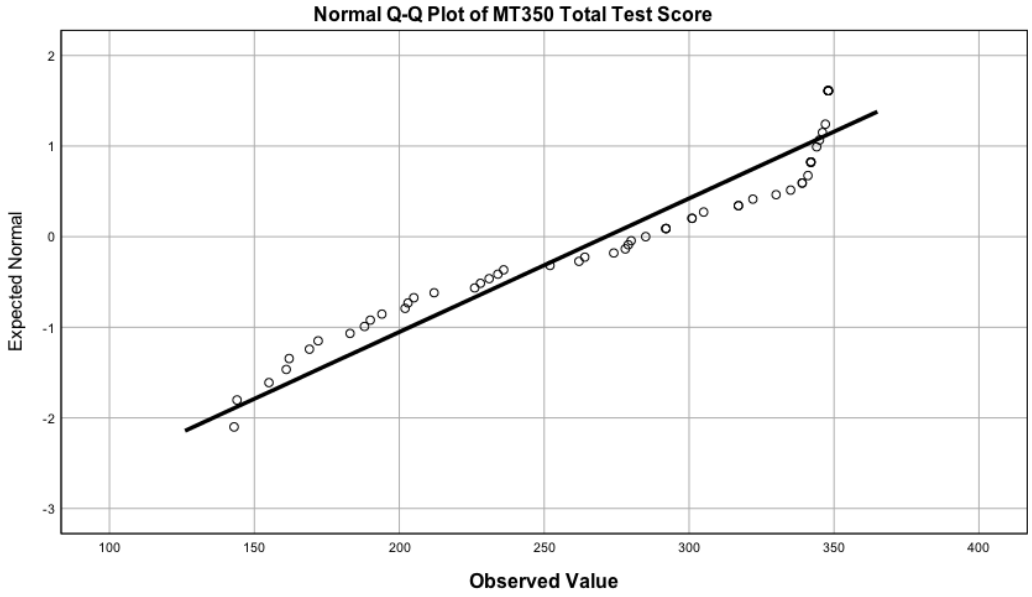

Figure 4. School 2 Q-Q Plot

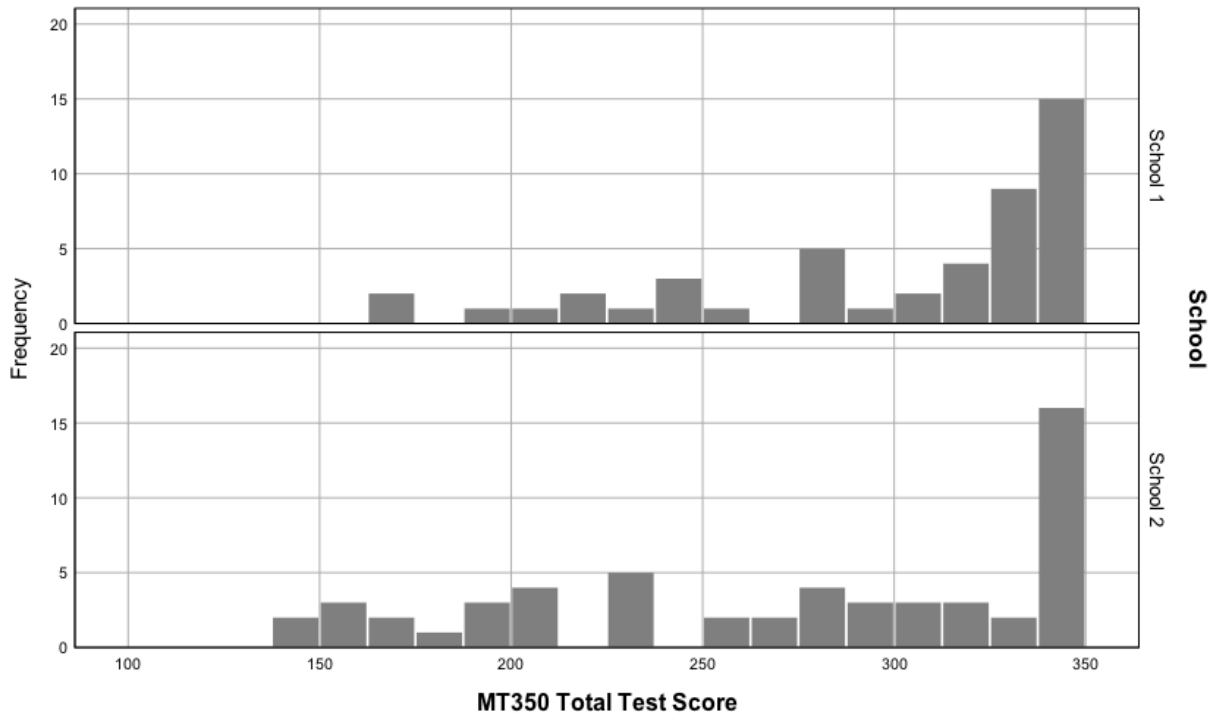

Figure 5. Frequency of MT350 Total Test Score by School

A Levene's test of equality was performed to evaluate the assumption of equality between the MT350 scores of the School 1 group and the School 2 group. The Levene's test failed to indicate equal variance, $F = 0.643$, $p = .013$. See Table 5 for the results of the Levene's test. An independent-samples t-test was conducted to determine if there is a statistically significant difference between the means of the MT350 scores for school 1 and school 2. The results of the independent t-test are indicated in Table 5. There was a significant difference in the scores for school 1 (M=300.83, SD=52.63) and school 2 (M=271.36, SD=67.81); t (99.13) = 2.46, $p = .01$. Cohen's effect size ($d = 0.486$) indicated a medium effect size. See Table 4 for descriptive statistics for School 1 and School 2.

Table 5

Independent Samples Test

		Levene's Test for Equality of Variances		*t*-test for Equality of Means		
Dependent variables		*F*	Sig.	*t*	*df*	Sig. (2-tailed)
MT350_Total_ Score	Equal variances assumed	6.430	.013	2.420	100	.017
	Equal variances not assumed			2.468	99.134	.015

Null Hypothesis One: Validity

The first null hypothesis stated that the MT350 instrument does not have an acceptable validity score greater than or equal to 0.62 as noted on CVI for assessing medical terminology retention among secondary health science students. In order to test $H_0$1 and examine the content validity of the MT350, 10 content experts in the field of health science education reviewed the MT350. Data obtained from the expert review (*N*=10) were analyzed to determine item CVR and MT350 CVI using Excel, with descriptive statistics analyzed using SPSS (25.0). Following Lawshe's content validity method, content experts (*N* = 10) rated each of the 350 MT350 items as 3 (essential), 2 (useful, but not essential), or 1 (not necessary). The researcher used the more stringent number of expert panel members (10) in order to report more robust findings, as five to 10 are preferred (Gilbert & Prion, 2016). The critical cutoff for establishing content validity for the MT350 with 10 content experts was a CVI no less than .62 (Lawshe, 1975). The CVR is the item statistic that is useful for retention or rejection of certain items, whereas the CVI is the mean of the CVR values. CVI of .377 failed to meet the acceptable validity of a CVI greater than or equal to .62; therefore, null hypothesis one failed to be rejected.

Content experts (*N*=10) reviewed all 350 items and were invited to provide comments or suggestions for improvement. A review of comments indicated that CE commonly focused on

the correct usage of the terms, instead of the essentiality (see Table 5). Expert panel commentary revealed item weakness(es) which may have contributed to a CVR item score of less than 3 (“essential”).

Table 6

Comments from the Expert Panel Review

MT350 Item	Expert Panel Comment
6. plast-	“Should be –plast”
8. path-	"Needs a combining vowel to be useful (-o-)"
10. -osis	"Needs a combining vowel to be useful (-o-)"
30. oid-	"Should be a -oid"
51. cost-	"Needs a combining vowel to be useful (-o-)"
54. rhexis	"Should be -rhexis”
76. lobo-	"Common knowledge"
83. cyt-	"Needs a combining vowel to be useful (-o-)"
97. cauda-	"Better as caud-"
99. myring-	"Needs a combining vowel to be useful (-o-)"
105. squam-	"I'm not familiar with this term"; "Needs a combining vowel to be useful (-o-)"
106. mening-	"Needs a combining vowel to be useful (-o-)"
107. cec-	"Needs a combining vowel to be useful (-o-)"
136. cor	"Should be cor-"
158. pod-	CE06 "Not a word part, a word"
160. adnexa-	"Not a word part, a word"

181. iris	"Not a word part"
226. mechano-	"Common knowledge"
258. tumor	"Not a word part"
259. vestibule	"Not a word part"
321. poster-	"Post- “essential”
337. fac-	"Common knowledge"

Null Hypothesis Two: Reliability

The second null hypothesis stated that the MT350 instrument does not have acceptable reliability score greater than or equal to 0.70 for measuring medical terminology retention among secondary health science students. In order to test $H_0$2 and evaluate the reliability of the MT350, a reliability calculator conducted the reliability analysis using the KR20 formula. The mean score of the MT350 items were 88.46 (SD= 14.32). The reliability analysis (KR20) from Microsoft Excel was conducted to evaluate the internal consistency of the MT350. The MT350 had a high level of internal consistency, as determined by a Cronbach’s alpha of 0.959. Based on these analyses, the null hypothesis for Research Question Two was rejected.

CHAPTER FIVE: CONCLUSIONS

Overview

In this final chapter, the researcher will discuss the various conclusions from the findings of this study. This chapter will include the purpose of the study, a discussion on each research question, and implications on how this study may add to existing knowledge of best medical terminology instructional and assessment strategies. Furthermore, the researcher will discuss limitations that impacted this study by identifying threats to both internal and external validity. Finally, recommendations for further research will be addressed and discussed.

Discussion

The purpose of this quantitative, psychometric analysis was to determine the reliability and validity of the Medical Terminology 350 Final Test (MT350) in a population of secondary health science students. This research examined archival data from MT350 scores of 102 secondary health science students. These students were identified as receiving medical terminology instruction in a secondary health science program. The students were from two schools in large metropolitan school systems in Missouri and Tennessee. Four secondary health science teachers administered the MT350 to all 102 students. All archival data were collected and stripped of student identifiable information prior to analysis.

Lawshe's (1975) content validity ratio equation was examined to determine the content validity of the MT350. Using a 3-point Likert-type scale, a panel of 10 content experts (CE) determined the degree to which the MT350 is valid instrument to measure concepts related to medical terminology. The research question that guided the research was as follows: "Is the MT350 a valid instrument to assess medical terminology retention learned by the keyword mnemonic method among secondary health science students?" Upon analysis using Lawshe's

(1975) CVR equation, the results established that the content expert panel did not determine the MT350 to be a valid instrument. The researcher failed to reject the null hypothesis: "The MT350 instrument does not have an acceptable validity score greater than or equal to 0.62 as noted on CVI for assessing medical terminology retention among secondary health science students." Concluding results of the expert panel participants' evaluation of the MT350 determined that the MT350 is not a valid assessment to measure concepts related to medical terminology.

The Kuder-Richardson 20 (KR20) formula was utilized to determine the internal consistency of the MT350. Prior to the psychometric properties being evaluated, violations of assumptions were checked to determine equal distribution of sample MT350 means from School 1 and School 2. Visual analysis screened data for normality. Normality was checked using a histogram for a symmetrical, bell-shaped curve. A scatter plot was used to check for the presence of extreme outliers, cigar shape, and linearity. The Levene's test for equality of variance was used to determine homogeneity of variance.

The research question answered by the analysis was as follows: "Is the MT350 a reliable instrument to assess medical terminology retention learned by the keyword mnemonic method among secondary health science students?" Upon analysis of the KR20, the results yielded that the MT350 is a reliable instrument. The researcher rejects the null hypothesis: "The MT350 instrument does not have acceptable reliability score greater than or equal to 0.70 for measuring medical terminology retention among secondary health science students." Results of the KR20 analysis determined the MT350 to be a reliable instrument to measure medical terminology retention.

Item analysis is a common method to determine validity when developing a new instrument. Lawshe's (1975) equation is often used to determine items on an instrument that should be

eliminated or revised. Kara and Celikler (2015) used items analysis to eliminate questions on a fifth-grade science achievement test when question distinctiveness was low (0.30). The present study is similar in using a content expert panel to analyze and rate individual items on an assessment. Instead of eliminating items (Kara & Celikler, 2015), the researcher will make suggestions to the proprietor of the MT350 concerning low CVR (0.50) items.

Content experts are commonly used in the development and revision of a test instrument (Bravo et al., 2016; Carter et al., 2016; Kara & Celikler; Wu et al., 2016) with two to 20 experts recommended (Carter et al., 2016), but five to 10 preferred (Gilbert & Prion, 2016). The present study consisted of the preferred number of content experts (n = 10) whereas previous studies had fewer content experts (Bravo et al., 2016, n = 8; Kara & Celikler, 2015, n = 4).

The design of this is similar to previous studies to evaluate the internal consistency in measuring healthcare competency (Bravo et al., 2016; Carter et al., 2016). Bravo et al. (2016) found the Safe Administration of Medications-Revised (SAM-R) scale a valid a reliable instrument to asses nursing student's knowledge to deliver medications. Bravo et al. determined the reliability of the SAM-R with a Cronbach's alpha (.736), whereas the present study concluded reliability with a higher Cronbach's alpha (.959). The present study consisted of 102 participants whereas fewer participants (Kazak et al., 2018; n = 79) and more participants (Bravo et al., 2016; n = 227) have been used in the past. Similar to previous studies that did not conclude an instrument to be valid and/or reliable (Kazak et al., 2018), the instrument may still be used but revisions may be necessary for future psychometric analysis.

This study is aligned with three learning theories that are uniquely different yet collaboratively effective in medical terminology retention. First, the cognitive learning theory (CLT) maintains that students learn best when an extraneous load is decreased, intrinsic load is

managed, and germane load is optimized (Young et al., 2014). This theory suggests that the keyword mnemonic method may best regulate schemata construction through a simplistic yet illogical visual approach. Second, the constructivist learning theory promotes learning through the reconstruction of new knowledge by connecting prior knowledge (Friberg, 2001). The keyword mnemonic method connects prior vocabulary knowledge to the formation and retention of new terminology. The keyword mnemonic method and constructivism are both idiosyncratic, active, and evolving processes that are operationalized by cognitive and metacognitive learning strategies (Anthony, 1996). Third, the experiential learning theory (ELT) is founded on the interests and preferences of the learner. This theory indicates integration of students' learning interests and preferences may foster an active learning environment. It is imperative to understand the relationship between learning theories and how students process and retain information. To determine this relationship, a psychometrically sound assessment instrument must be used.

Research exists that the acquisition of medical terminology is a key factor in future employment in health science professions (Brahler & Walker, 2008; Wang et al., 2016). Considering the goal of career and technical education (CTE) is to provide students with employable skills (Rabren et al., 2014; Stipanovic et al., 2012), there is a need for effective instructional strategies in medical terminology. While literature supports the need for effective teaching and learning strategies related to medical terminology, there is limited investigated best practices (Hull, 2016).

Keyword mnemonics has been found effective in reducing difficulties in retention of difficult vocabulary, such as medical terminology (Davoudi & Yousefi, 2016). To date, one study has investigated the effectiveness of the Dean Vaughn Medical Terminology 350 as a

keyword mnemonic instructional and learning strategy (Brahler & Walker, 2008). The present study examined the psychometric properties of the MT350 which Brahler and Walker (2008) used to measure pre- to posttest word recall improvement. Research upholds the need to confirm the reliability and validity of instruments used to assess students to assure integrity of research findings (DeVon et al., 2007).

Implications

Results of the validity and reliability of the MT350 in this study provide health science educators an evidence-based instructional strategy to enhance student medical terminology recall. Up to now, literature has been silent on best teaching and learning practices in medical terminology (Shoemaker & Kelly, 2015).

Additionally, this study begins to establish the MT350 as a valid and reliable medical terminology assessment for secondary health science students. This is significant as the MT350 psychometric properties of validity and reliability had not been previously determined; thus, findings from this study fills a gap in literature. Knowledge of the psychometric properties of the MT350 may also add to educational literature medical terminology assessment strategies. Determining a valid and reliable medical terminology assessment tool, future quantitative studies may measure best teaching and learning practices.

This study has implications for medical terminology teaching and learning among secondary health science programs in career and technical education. Health science educators' goal is to provide students with employable skills (Rabren et al., 2014; Stipanovic et al., 2012) by utilizing the most effective teaching and learning strategies (Stringfield et al., 2013). However, health science educators are historically underprepared in effective instructional and assessment practices (Fletcher & Djajalaksana, 2014).

Student mastery on the MT350 may also determine employable communication skills. The acquisition of communication skills is a key factor for successfully achieving skills for future employment in health science professions (Brahler & Walker, 2008; Wang et al., 2016).

Limitations

This study analyzed archival data from two secondary schools in two states, which could limit generalizability. A larger collection of archival MT350 data from different states, various sized schools, urban, rural locations may determine the psychometric properties of the MT350 with more generalizability. This study also did not analyze student demographic characteristics such as gender, race, age, and grade level, so it was unable to determine if results varied between biological sex and race.

Differences in instructional implementation are a limitation to this study. The lack of methodological control between course instruction is a threat to internal validity. While the Medical Terminology 350 course provides an instructor's resource manual, it cannot be assumed that all participating teachers implemented the course synonymously. Additionally, a MT350 instrumentation limitation is a non-response limitation when MT350 items were not answered by the respondent.

Although the content expert panel was sufficient in size according to research (Carter et al., 2016; Gilbert & Prion, 2016), a small sample of 10 content experts is a limitation to this study. Lastly, an additional limitation is participant bias among the CE panel. The interpretations of each medical element may have been affected by the participant's profession and knowledge of the medical element. Interpanelist differences may have contributed to a lack of rating coherence. The researcher established certain criteria for the CE panel in this study; however, there was a range of professional backgrounds and expertise.

Recommendations for Future Research

The study has determined the validity and reliability of the MT350, linking this population of secondary health science students to a commonly used medical terminology assessment. This study, while finding the psychometric properties of the MT350, is not without need for further investigating the Dean Vaughn Medical Terminology 350 course and the MT350.

The following recommendations are made:

1. Administer a revised validation instrument for content expert review to include definitions of terms.
2. Further examination of Dean Vaughn's Medical Terminology 350 course might study the comparative effects of the online format versus the paper format. Findings may determine the most effective course instructional method.
3. To gain a better understanding of the MT350, the researcher suggests evaluating the psychometric properties of the MT350 online format.
4. Additionally, a larger sample size (N =102) may contribute to a more robust analysis.
5. The researcher's next recommendation is to obtain a larger collection of archival MT350 scores in different states, various sized schools, both urban and rural.
6. Administer a qualitative assessment of student self-efficacy and its impact on MT350 performance. The MT350 survey findings from this study were consistent with content experts who evaluated the essentiality of each item on the MT350.
7. Using the MT350 results to predict student achievement on high stakes tests, such as an industry certification or licensure examination.

8. Lastly, evaluating the reliability of the MT350 among postsecondary students may broaden the generalizability and fill a gap in literature regarding a valid medical terminology assessment across various populations.

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APPENDIX A: IRB Application

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

January 21, 2019

Kristen Bowers
IRB Exemption 3551.012119: Psychometric Analysis of the Medical Terminology 350 Final Test Using Item Analysis and KR20

Dear Kristen Bowers,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under exemption category 46.101(b)(2), which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:101(b):

> (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
> (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.
>
> (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

Please note that this exemption only applies to your current research application, and any changes to your protocol must be reported to the Liberty IRB for verification of continued exemption status. You may report these changes by submitting a change in protocol form or a new application to the IRB and referencing the above IRB Exemption number.

If you have any questions about this exemption or need assistance in determining whether possible changes to your protocol would change your exemption status, please email us at irb@liberty.edu.

Sincerely,

[redacted]

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office

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APPENDIX B: Copyright Permission

September 26, 2018

Dear Permissions Editor Robert Maddestra:

I am a doctoral student at Liberty University, conducting research on the psychometric properties of the Medical Terminology 350 Final Test. I would like your permission to include the following material in my dissertation:

> Citation of the Dean Vaughn Total Retention System Medical Terminology 350, image, and Medical Terminology 350 Final Test.

The title of my dissertation is the "Psychometric Analysis of the Medical Terminology 350 Final Test Using Item Analysis and KR20." This research seeks to determine the validity and reliability of the Medical Terminology 350 Final Test to provide educators with a psychometrically sound assessment.

If you do not control the copyright on all of the above-mentioned material, I would appreciate any contact information you can give me regarding the proper rights holder(s), including current address(es). Otherwise, your permission confirms that you hold the right to grant the permission requested here.

Permission includes non-exclusive world rights in all languages to use the material and will not limit any future publications-including future editions and revisions.

I would greatly appreciate your consent to my request. If you require any additional information, please do not hesitate to contact me. I can be reached at:

[redacted]

If you agree with the terms as described above, please sign the release form below and email to [redacted]

Sincerely,

Kristen Bowers

Permission granted for the use of the material as described above:

Agreed to: _____ Name & Title: _____
Company/Affiliation: _____ Date: _____

APPENDIX C: Permission Request

Robert Maddestra
National Sales Director
Dean Vaughn Total Retention System™
8740 Lucent Boulevard
Suite 400
Highlands Ranch, CO 80129

Dear Mr. Maddestra,

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a doctoral degree. The title of my research project is Psychometric Analysis of the Medical Terminology 350 Final Test Using Item Analysis and KR20, and the purpose of my research is to determine if the MT350 is a valid and reliable measure of productive medical terminology retention.

I am writing to request your permission to access and utilize student test records from the Medical Terminology 350 Final Test.

The archival data will be used to determine the validity and reliability of the Medical Terminology 350 Final Test. Providing archival data for this study is completely voluntary, and participation may be discontinued at any time.

Thank you for considering my request. If you choose to grant permission, please provide a signed statement on official letterhead indicating your approval and respond by email to researcher kbowers6@liberty.edu.

Sincerely,

Kristen Bowers
Doctoral Candidate at Liberty University
Health Science Teacher

APPENDIX D: Expert Panel Request for Participation

Dear Colleague,

My name is Kristen Bowers and I am a doctoral student at Liberty University in the School of Education. I am currently working on my dissertation and am ready to begin data collection on the validity of the Medical Terminology 350 Final Test (MT350).

Based on your expertise in the field of health and education, you are invited to be part of an expert panel that is an integral part of my doctoral research to assist in the evaluation of the MT350 psychometric properties. The purpose of this study is to determine the reliability and validity of the Medical Terminology 350 Final Test (MT350) in a population of secondary and postsecondary health science students. In doing so, it can be determined if this instrument can be used in future investigations on best teaching and learning strategies for keyword mnemonic methods.

The Medical Terminology Final Test was developed by the Dean Vaughn Total Retention System as a final assessment to determine students' medical terminology recall. The MT350 is a 350-question assessment that requires the student to print the meaning of each element. A space is also provided for the participant to include the audionym as an aid to recall the meaning (Vaughn, D. E & DCM Instructional Systems, 2006). Participants are only scored on the meanings of the elements (Vaughn, D. E & DCM Instructional Systems, 2006). It is vital to evaluate the MT350 instrument because of the importance of 1) medical terminology knowledge to the healthcare profession, 2) effective vocabulary instructional strategies, 3) the cognitive load theory in learning vocabulary, and 4) having a confirmed reliable and valid instrument to measure medical terminology retention using the keyword mnemonic method.

If you agree to participate in this research study: please read and sign the attached consent form, complete the attached survey, and email both documents to me. You are welcomed to type your name and the date on the consent form as opposed to printing, physically signing, scanning, and returning. If you wish to be recognized for your participation in this study for publication purposes, please check the box under the signature line on the consent form. If you do not wish to be recognized, your participation will remain confidential.

In the survey you will rate each of the 350 items of the MT350 based on the question and

You may contact me at knbowers6@liberty.edu if you have any questions, or I can be reached at [redacted].

Sincerely,
Kristen Bowers

APPENDIX E: Informed Consent

CONSENT FORM

Psychometric Analysis of the Medical Terminology 350 Final Test
Using Item Analysis and KR20

Kristen Bowers
Liberty University
School of Education

You are invited to be in a research study on the psychometric analysis of the Medical Terminology 350 Final Test, to include validity and reliability. You were selected as a possible participant because you are considered a content expert as a health science colleague and/or curriculum leader. To be included in this study participants must have a background in health, experience in education, minimum of a Master's degree, and English as a primary language. Please read this form and ask any questions you may have before agreeing to be in the study.

Kristen Bowers, a doctoral candidate in the School of Education at Liberty University, is conducting this study.

Background Information: The purpose of this study is to determine the reliability and validity of the Medical Terminology 350 Final Test (MT350) using archival data in a population of secondary and postsecondary health science students. The core research question is: is the Medical Terminology 350 Final Test (MT350) a valid and reliable instrument to assess medical terminology retention learned by the keyword mnemonic method among secondary and postsecondary health science students? A study to determine if the MT350 is a valid and reliable instrument will inform educational practice on an acceptable instrument to measure medical terminology retention. In doing so, it can be determined if this instrument can be used in future investigations on best teaching and learning strategies for keyword mnemonic methods

Procedures: If you agree to be in this study, I would ask you to do the following things:

1. Complete the survey by rating all 350 items from the MT350 on a 3-point Likert-type scale. Email the completed survey to the researcher at kbowers6@liberty.edu. The survey is estimated to take one hour.

Risks: The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

Benefits: Participants should not expect to receive a direct benefit from taking part in this study. Benefits to society include determining an evidence-based method to assess medical terminology retention may result in a curricula directional shift in health science programs

Compensation: Participants will not be compensated for participating in this study.

Confidentiality: The records of this study will be kept private. In any sort of report I might publish, I will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records.

I may share the data I collect from you for use in future research studies or with other researchers; if I share the data that I collect about you, I will remove any information that could identify you, if applicable, before I share the data. Participants will be assigned an ID number, CE01-CE05. Data will be stored on a password locked computer and may be used in future presentations. After three years, all records will be deleted.

Voluntary Nature of the Study: Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Liberty University. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

How to Withdraw from the Study: If you choose to withdraw from the study, please contact the researcher at the email address/phone number included in the next paragraph. Should you choose to withdraw, data collected from you, will be destroyed immediately and will not be included in this study.

Contacts and Questions: The researcher conducting this study is Kristen Bowers. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at Kbowers6@liberty.edu. You may also contact the researcher's faculty chair, Dr. Mattson, at djmattson@liberty.edu

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Please notify the researcher if you would like a copy of this information for your records.

Statement of Consent: I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

_____

Signature of Participant Date

_____

Signature of Investigator Date

APPENDIX F: Validation Instrument for Content Expert Review

Please rate all MT350 items on a 3-point Likert-type scale by responding to the following question: Is the medical element measured by this item (3 = essential, 2 = useful, but not essential, 1 = not necessary) to the performance of measuring medical terminology knowledge. Please rate by placing a X in the appropriate box.

MT350 Item	Essential (3)	Useful, but not Essential (2)	Not Necessary (1)	Comments
1. gastr-				
2. cardi-				
3. megal-				
4. -itis				
5. dermat-				
6. plast-				
7. cerebr-				
8. path-				
9. -ectomy				
10. enter-				
11. -osis				
12. -otomy				
13. aden-				
14. angi-				
15 . -oma				
16. nephr-				
17. hepat-				
18, arthr-				
19. blephar-				
20. -ologist				
21. rhin-				
22. gingiv-				
23. -malacia				
24. -ology				
25. spasm				
26. -algia				
27. crani-				
28. end-				
29. hemi				
30. oid-				
31. hyper-				
32. cyst-				
33. chole-				
34. hypo-				
35. -scop				
36. hyster-				
37. -ostomy				

MT350 Item	Essential (3)	Useful, but not Essential (2)	Not Necessary (1)	Comments
38. para-				
39. -lysis				
40. cervic-				
41. chrondr-				
42. cyan-				
43. hem(at)-				
44. ost--				
45. psycho-				
46. lip-				
47. my-				
48. lith-				
49. ophthalm-, opt-				
50. proct-				
51. cost-				
52. -gram				
53. acro-				
54. rhexis				
55. carcin				
56. -penia				
57. gen-				
58. burso-				
59. retr(o)-				
60. trip				
61. strept-				
62. -desis				
63. mani-				
64. glosso-				
65. -trophy				
66. supra-				
67. -ptosis				
68. dyn-				
69. mast-				
70. -rrhaphy				
71. dent-				
72. cephal-				
73. auto-				
74. epi-				
75. hydro-				
76. lobo-				
77. -emesis				
78. contra-				
79. -iasis				
80. trans-				
81. brady-				
82. -ectasis				

MT350 Item	Essential (3)	Useful, but not Essential (2)	Not Necessary (1)	Comments
83. cyt-				
84. odont-				
85. leuk-				
86. -esthesia				
87. cantho-				
88. steno-				
89. cheil-				
90. -cele				
91. benign				
92. semen				
93. celio-				
94. erythro-				
95. vaso-				
96. melan-				
97. cauda-				
98. lingua-				
99. myring-				
100. spondyl-				
101. ovar-				
102. -centesis				
103. oto-				
104. bili-				
105. squam-				
106. mening-				
107. cec-				
108. macul-				
109. -pexy				
110. onco-				
111. or-				
112. sub-				
113. spiro-				
114. lacrim				
115. viscero-				
116. lact-				
117. onych-				
118. thorac-				
119. pyle, pyloro-				
120. vesic-				
121. sphenic-				
122. myel-				
123. anti-				
124. myco-				
125. hallux-				
126. physio-				
127. bucco-				

MT350 Item	Essential (3)	Useful, but not Essential (2)	Not Necessary (1)	Comments
128. palpebr-				
129. plasia-				
130. rug-				
131. aur-				
132. acousti-				
133. colpo-				
134. phon-				
135. leio-				
136. cor				
137. ren-				
138. orchi-				
139. encephal-				
140. thalam-				
141. plexus				
142. cilia				
143. dendr-				
144. phleb-				
145. pilo-				
146. histo-				
147. stoma-				
148. tympan-				
149. umbilic-				
150. salpingo-				
151. helio-				
152. astr-				
153. -asthenia				
154. fascia				
155. iso-				
156. tarso-				
157. -tope				
158. pod-				
159. malign-				
160. adnexa-				
161. ocul-				
162. lapar-				
163. dacry-				
164. ment-				
165. part-				
166. scler(a)-				
167. somato-				
168. trachel-				
169. sinus				
170. hypno-				
171. sept-				
172. scirr(h)-				

MT350 Item	Essential (3)	Useful, but not Essential (2)	Not Necessary (1)	Comments
173. antr-				
174. crine				
175.dura-				
176. pneum-				
177. phage				
178. phren-				
179. corne-				
180. plak-				
181. iris				
182. kerat-				
183. pulmon-				
184. ptyal-				
185. alveol-				
186. oophor-				
187. oment-				
188. sedat-				
189. furca-				
190. radic-				
191. radi-				
192. fistul-				
193. edema-				
194. dactyl-				
195. metabol(e)-				
196. pariet-				
197. ependym-				
198. gravid				
199. aer-				
200. glyco-				
201. tarso-				
202. cheir-, chir-				
203. calc-				
204. cine-				
205. digit				
206. dors-				
207. gangli-				
208. gemin-				
209. grad-				
210. gran-				
211. labi-				
212. micr-				
213. peps-, pept				
214. pleur-				
215. mamm-				
216. colla-				
217. later-				

MT350 Item	Essential (3)	Useful, but not Essential (2)	Not Necessary (1)	Comments
218. rachi-				
219. phob-				
220. phot-				
221. dys-				
222. cut-				
223. en-				
224. peri-				
225. pro-				
226. mechano-				
227. dynam-				
228. osmo-				
229. traumat-				
230. trich-				
231. maxill-				
232. an-, a-				
233. phak-				
234. pre-				
235. strict-				
236. turbin-				
237. ameb-				
238. semi-				
239. neo-				
240. hormone				
241. therm-				
242. syn-, sym-				
243. vuls(e)-				
244. post				
245. metr-				
246. tegument				
247. pan				
248. poly-				
249. ramus				
250. neuro				
251. thromb-				
252. ab-				
253. -plegia				
254. ante-				
255. thel-				
256. ex-				
257. lien-				
258. tumor				
259. vestibule				
260. puer-				
261. sarc-				
262. proli-				

MT350 Item	Essential (3)	Useful, but not Essential (2)	Not Necessary (1)	Comments
263. macro-				
264. lal-				
265. intra-				
266. inter-				
267. infra-				
268. cryo-				
269. mal-				
270. glom-				
271. tens-				
272. spas-				
273. somni-				
274. pharmac-				
275. lumbo-				
276. arter-				
277. appendic-				
278. thryo-				
279. splen-				
280. ovario-				
281. adreno-				
282. basi-				
283. pelvi-				
284. vena-				
285. urethr-				
286. utero-				
287. scaro-				
288. pharyng-				
289. duodeno-				
290. ureter-				
291. laryng-				
292. bronch-				
293. col-				
294. esophag-				
295. bi-				
296. tri-				
297. ile-				
298. ili-				
299. lig-				
300. therap-				
301. ventr-				
302. vert-				
303. eu-				
304. ambi-				
305. amphi-				
306. brachy-				
307. capit-				

MT350 Item	Essential (3)	Useful, but not Essential (2)	Not Necessary (1)	Comments
308. cau-				
309. clas-				
310. duct-				
311. fiss-				
312. ger-				
313. heter-				
314. infer-				
315. hom-				
316. olfact-				
317. orth-				
318. gyn-				
319. pachy-				
320. phrag-				
321. poster-				
322. cata-				
323. platy-				
324. pseud-				
325. schiz-				
326. proxim-				
327. scol-				
328. apo-				
329. di-				
330. dia-				
331. eury-				
332. pect-				
333. necr-				
334. mi-				
335. morph-				
336. dis-				
337. fac-				
338. lept-				
339. lymph-				
340. meta-				
341. -rrhag				
342. sta-				
343. ton-				
344. volv-				
345. splanchn				
346. -rrhe				
347. med--				
348. xer-				
349. per-				
350. blast-				