UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

APPLYING THE UNIVERSAL DESIGN FOR LEARNING IN HIGHER EDUCATION; A GUIDE FOR INCREASED LEARNING IN THE CLASSROOM

A THESIS

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

MASTER OF SCIENCE

By

MELISSA ROSA PLATA

Norman, Oklahoma

2020

APPLYING THE UNIVERSAL DESIGN FOR LEARNING IN HIGHER EDUCATION; A GUIDE FOR INCREASED LEARNING IN THE CLASSROOM

A THESIS APPROVED FOR THE

SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING

BY THE COMMITTEE CONSISTING OF

Dr. Ziho Kang, Chair

Dr. Janet K. Allen

Dr. Randa L. Shehab

This thesis is dedicated to my parents, who raised me in a house full of happiness, love, and pride for my homeland.

Acknowledgments

I would like to express my appreciation and gratitude to my advisor, Dr. Kang; for providing mentorship and guidance throughout this journey. Thank you to Dr. Shehab and Dr. Allen for your valued time and guidance. Additionally, thank you to Dr. Raman for giving me a place at OU. Thanks to my lab mates Amin Alhashim and Rashmi Reddy Annadi for their hard work in the experiment that fueled this thesis topic, it would not have been possible without you. A special thanks to all my friends at OU for their encouragement.

Thank you to the FAA Academy for providing the funding for this experiment; specially Mr. Keith Deberry, Director of FAA Academy and Dr. Jerry Crutchfield, Engineering Research Psychologist at FAA Civil Aerospace Medical Institute (CAMI).

Thank you to my parents, “Mami Mari y Papi Mito”, I love you with all my heart. Thank you for being excellent parents, for always giving me unconditional support no matter what I wanted to pursue in life and for making me appreciate childhood while I was a child. Thanks to my sister Isa for being my role model, my best friend for life, for your unlimited kindness towards everyone, and for always the best example to follow. To my best friend and boyfriend of too many years Jose for being responsible, driven and begging me to come keep you company in Oklahoma.

Finally, thanks to God for leading me down the crazy paths of life; through doors I never thought I would travel. I am looking forward to discovering what path you will lead me down next...

Table of Contents

List of Figures

List of Tables

Abstract

Education is essential for societal progress. Therefore, increasing performance in learning has become a popular research topic. However, determining this has proven difficult as all humans learn differently.

The Universal Design for Learning (UDL) has focused on providing a set of intuitive teaching and course design guidelines that can increase learning (CAST, 2018; Meyer, Rose, & Gordon, 2014). UDL concepts have been implemented in K-12 education levels with successful outputs. However, these techniques effectiveness have been sparsely tested in higher education coursework. A study was conducted for this thesis that strived to determine the effectiveness of the UDL framework when applied in the higher education (HE).

A set of slides implementing the UDL principles were created for this experiment from an existing aviation course. Thirty-six students from the University of Oklahoma participated in studying sample slides from either the UDL inspired content or Original course content. The subjects' eye movement fixation duration, eye fixation count, pupil size and quiz results, were statistically analyzed to determine significance. The analyzed measures provided a way to quantify students engagement. This served to compare if enhancements using UDL were effective when applied to contents found in higher education. Additionally, a brief exit survey was conducted to further validate engagement and interest from the participants

The results revealed an improvement when UDL contents are applied. Quiz result significantly improved with the UDL inspired contents. Eye movement fixation duration

and eye fixation counts were higher for the UDL contents. Participants that had UDL enhanced contents had slightly higher pupil dilation which could be linked to greater focus. Finally UDL participants expressed higher levels of satisfaction and interest in the exit survey.

Results indicated that when UDL contents were applied to learning materials students' scores improved overall; additionally the longer eye fixation duration and eye fixation counts associates to an increase in attention. Therefore, implementing UDL into the higher education learning process shows promise in enhancing students' scores and overall attentiveness.

Keywords: Universal Design for Learning (UDL), Eye Tracking, Higher Education

Author's note: This research was conducted based on the project funded by the Federal Aviation Administration titled "Universal Design for Learning and Multimodal Training" (Project No. A17-0161; Lead PI: Dr. Ziho Kang). The contents of the thesis will be submitted as a journal paper.

CHAPTER 1: Introduction

1.1 Summary

In most aspects of our life technology has been a facilitator. It has generally freed us of the burden of mundane tasks, like hand washing clothes, doing dishes, walking to the store, having to buy the multiple volumes of Encyclopedia Britannica to do homework, etc. However, akin to most wonderful things, technology is not without its downfalls.

In education students have transitioned into a new breed of learner. A learner that is increasingly more distracted and thrives on instant gratification, rather than hard work and perseverance. Thus, educators must find a way to get through to this new kind of students; bypassing all distractions and internet cat pictures in order to create a well-rounded functional learner that will go out and contribute to society.

Education has changed significantly during the past century. Well educated individuals, that came from families without means, can thrive in today's modern society. With technological advances like the internet, knowledge can be acquired with the press of a button. A formal education can now be obtained online without ever setting foot in the classroom. Therefore, educators must evolve and adapt to today's high technological society while still providing the advantages of a classroom setting.

This introduction (Chapter 1) will form the foundation of this thesis by discussing certain aspects of education and the UDL methodology that can be applied in the hopes of increasing focus and creating an equal opportunity environment for students. Specifically, students that are pursuing higher education. Chapter 2 provides a literature review of relevant works. It gives some background as to what UDL is and how it has been used in

the past. Chapter 3: Problem Definition, explains in a succinct way the experimental objective and its constraints. Chapter 4 presents the methodology in which this experiment was conducted; in this chapter the experimental procedures that aided in the collection of data for the UDL experiment will be highlighted. Results and the discussion of the results of the experiment can be found in Chapter 5. This thesis ends by providing this study's limitations and some ideas into what future research could be done in Chapter 6 and some brief concluding remarks in Chapter 7.

1.2 Human Factors, UDL and Education

Though UDL is not explicitly a Human Factors approach it aligns with it in many ways. Human Factors can be defined as: "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Practitioners of ergonomics and ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people."(IEA, n.d.). In other words: Human Factors influences the way interactions of humans with systems occur, by enhancing their designs. Thus, there can be ways in which we can use methods and principles, that align with those taught in human factors, and are applicable to education. UDL has the potential to reshape the education system by providing a structured methodology that focuses on reaching a

broader audience by improving course design. Education as a system could be re-designed with the goal of increasing student's attentiveness and overall satisfaction.

1.3 Universal Design for Learning

The "how" in learning varies from student to student. The Universal Design for Learning(UDL) strives to create/ design and all-inclusive learning curriculum that aids students by providing multiple means of learning the concepts provided (CAST, 2018). UDL is not a new concept, its origins date back to before the 1990's (Meyer et al., 2014; Tobin, 2018). Even though UDL is around 30 years old, it has still not been fully adopted at a higher educational level. The slow application of the concepts taught in UDL could be due to its initial branding as being focused on students with learning disabilities; however the UDL framework is universal in providing scaffolding and focused on improving the contents of an institution to offer options for diverse learning. UDL is based on CAST's (Center for Applied Special Technology) research related to three primary brain networks (recognition network, strategic network, and affective network) and the roles they play in understanding new learning material. The framework was developed on the basis of neuroscience, to stimulate different areas of the brain that could potentially enhance learning and education.

With the rise of the digital age, information is readily accessible; UDL recognizes this as an advantage. For UDL learning is broken down into three parts. The three principles that make up the UDL framework are the following: Provide Multiple Means of Representation (the "what" of learning), Provide Multiple Means of Action and Expression

(the “how” of learning) and Provide Multiple Means of Engagement (the “why” of learning). All the principles and their corresponding features can be found in Figure 1. The principle implemented into the contents for this experiment was *Provide Multiple Means of Representation*. This was due to the nature of the experiment, as the slide sets were modified to conform with said principle. The two other principles were determined not applicable for a highly controlled experimental environment. Nevertheless, they are summarized below due to the added value they can provide for a full course implementation.

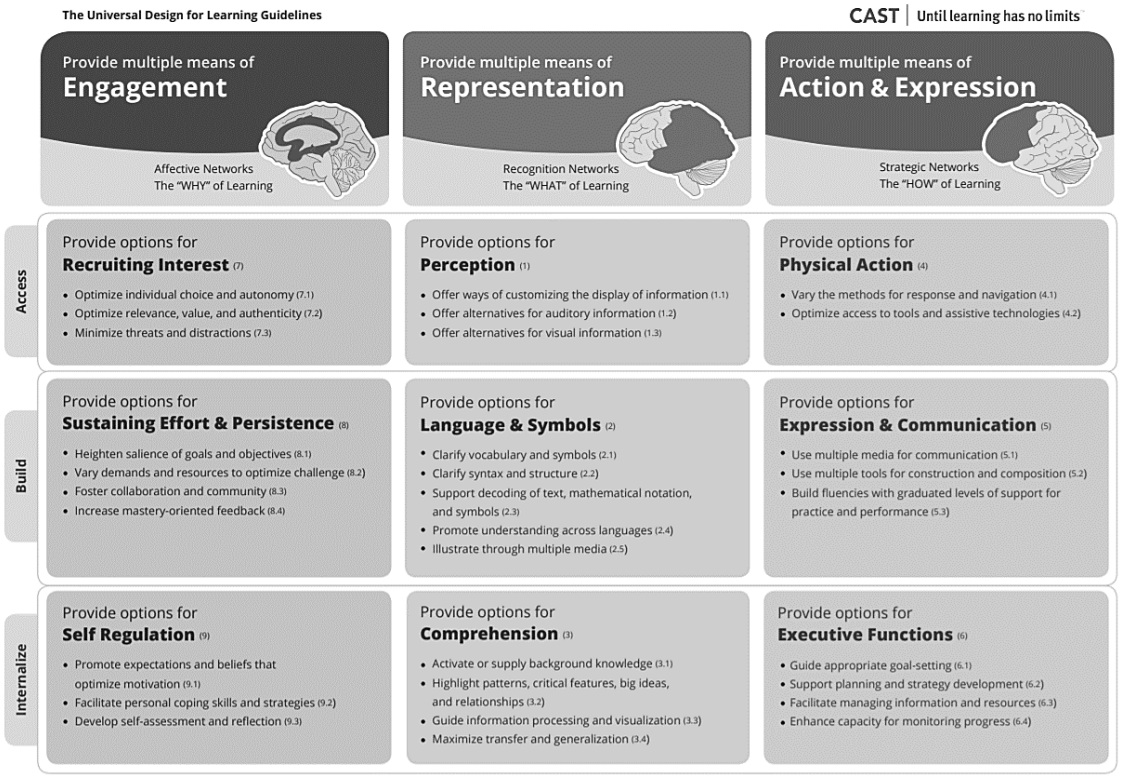


Figure 1. CAST (2018). Universal design for learning guidelines version 2.2 [graphic organizer].

1.3.1 Provide Multiple Means of Representation

When multiple representations are used students can make connections within concepts, enhancing their learning (Meyer et al., 2014). The way information is perceived and comprehended varies from person to person. Therefore, there is no 'representation' that will be optimal for all learners; providing options for representation is essential. When only visual pathways are presented some students struggle to interpret text and understand the learning material. This is the principle that can be easier for instructors to directly implement into course. It focuses on enhancing the content provided for the students to learn the concept taught (e.g. Pdfs, Word documents, Power Point slides, etc.). This is the main UDL principle was used in this experiment. Specifically, the following concepts, found within the principle, were used as guidelines to enhance the aviation course slide set: illustrate through multiple media (e.g. providing additional visual guidance, table, diagrams, charts, etc.),offering alternatives for visual information (e.g. Voice over/Text to Speech), provide descriptions (text or spoken), make relationships between elements explicit (e.g. highlight or emphasize key elements in text, graphics, diagrams, formulas, etc.), Use examples to emphasize elements (Activate or supply background knowledge) and guide information processing and visualization (e.g. "Chunk" information into smaller elements).

1.3.2 Provide Multiple Means of Action and Expression

Navigating a learning environment and expressing what is known is different for each learner. Some may be able to express themselves in written text but not speech, and vice

versa. This principle focuses primarily of what physical hardware, programs and tools can be provided to enhance the learning environment. It also provides strategies for goal setting , planning and strategy development for learning the contents taught. Moreover it states the importance of facilitating students with resources to manage information and monitor their progress. For this experiment this principle could not be integrated into the enhanced contents. Nevertheless it is an important principle to consider when implementing this methodology in a real learning environment.

1.3.3 Provide Multiple Means of Engagement

Students differ in the ways in which they can be engaged or motivated to learn. Many sources can influence variation including neurology, culture, personal relevance, subjectivity, and background knowledge. This principle focuses on providing an environment focused on feedback to the student and providing them with tools to gather important information effectively. For example: some learners might like to work alone, while others prefer groups; thus providing an option for both would be ideal. This principle recommends recruiting learner attention by providing information and activities that are relevant and valuable to their interests and goals. Since a controlled environment was created in this experiment there was no risk of distractions that could affect the learning environment. Furthermore, the subject's goals would be to complete the experiment thus the effectiveness of this principle was not tested within the constraints of this experiment. It is worth noting that though our subjects would be properly engaged due to the nature of

the experiment, this is a very important principle that should be implemented in higher educational environments to scaffold pedagogy.

1.4 Objective

Materials enhanced with Universal Design for Learning concepts were presented to university students. To validate an increase in learning, students' performance was measured by analyzing quiz scores(i.e. number of correct responses); additionally engagement (i.e. eye tracking measures) and verbalized interest (i.e. exit survey) were evaluated. The statistically analyzed measurements of eye fixation count, eye fixation duration, pupil dilation and quiz results were used to determine the effectiveness of the UDL framework when applied to higher education (HE).

CHAPTER 2: Background

Summary

In Chapter 2 a literature review was conducted to verify existing literature and technologies with applied UDL methodology. We begin with a look at UDL, its origins and how it has positively affected education. We then continue with a summarized table of the benchmarking of UDL applications performed prior to conducting the experiment. Finally, we conclude this literature with a brief background into eye tracking measures, and how these measurements have been used in the past for experimental validation in other fields.

2.1 Universal Design for Learning

2.1.1 Background into UDL and Higher Education

The concept of "universal design" can be traced back 1950's architecture, when houses began to be designed so that the aging population could use their home as long as possible (Tobin, 2018). There are four essential qualities in a product design that qualify it as an universal design: supportive, adaptable, accessible and safety oriented (Null, 2013). Universal Design reduces the need of accommodation by integrating these qualities into the design itself that way making the adjustability available to anyone instead of modifying it for a specific case as needed. The Center for Applied Special Technology (CAST) restructured their methods around 1996 by shifting their focus from the individual learner to classroom, course design and the education system that could benefit all; therein coining the term *Universal Design for Learning* (i.e. UDL) (CAST, 2018).

When developing course materials, it's important to consider how they are designed. How course contents are designed could potentially impact the learning and material retention of students. A way to potentially increase learning is to provide multiple options to study said materials; engaging students and creating a flexible education environment. There are multiple strategies that have been developed through the years on the premise of improving aspects of education to benefit the learner (e.g. learning styles, Blooms' taxonomy, situational interest, etc.). Blooms' taxonomy similar to that of UDL categorizes learning and educational objectives into three main categories cognitive, psychomotor, and affective (Meyer et al., 2014). However, although many learning strategies exist, UDL possesses a robust platform geared towards designing course contents to accommodate each and every learner. The UDL methodology has the potential to greatly benefit environments like conferences, universities and organizational certifications; where a diverse group of individuals are all expected to benefit from receiving the same contents.

UDL for higher education has been scarcely implemented, with a 10% adoption rate from faculty (Murray, Lombardi, Wren, & Keys, 2009; Tobin, 2018) Tobin (2018) expressed that extensive research has been conducted related to accommodation in higher education and faculty reception has been negative. This could be due to UDL being primarily associated with disability and accommodation. From the surveyed literature it is evident that most of the research conducted about UDL to this day centers around how its benefits students with learning challenges and in need of special accommodation due to disability (Coyne, Pisha, Dalton, Zeph, & Smith, 2012; Cunningham & Murphy, 2018; Goforth-Melroy, 2014; Gravel, 2017; Hall, Meyer, & Rose, 2012; Lohmann, Boothe,

Hathcote, & Turpin, 2018; Marino et al., 2014; Messinger-Willman & Marino, 2010; Meyer et al., 2014; Mundorf, 2014; Murawski & Scott, 2019; Novak & Rose, 2016; Parker, 2013; Rappolt-Schlichtmann et al., 2013; Rose, 2002; Vie, 2018; Webb & Hoover, 2015).

Thinking of UDL as only a resource for the disabled is a misconstruction. This universal design could help bridge the gap that has been created in today's higher education learning environment. Inclusivity and accessibility do not solely benefit the disabled. Students today require different teaching strategies than those of 20 years ago. Keeping the students engaged and focused on the lecture at hand should be a priority for higher education instructors. Some college students could have difficulty focusing or an invisible illness (e.g. ADD, ADHD, depression, addiction, anxiety, etc.). It's estimated that about 15% of university students have some form of mental illness (Brockelman & Scheyett, 2015).

Additional distractions now occur in classrooms. Ninety four percent(94%) of people eighteen to twenty-four own a smartphone; 59% of people use their smartphone for personal use during normal working hours "very/fairly often" (Deloitte, 2018). Americans view their smartphone an average of 52 times per day. A Baylor study with 164 college participants found that college girls spend 10 hours daily on their phone and boys spend around 8 hours (Roberts, Yaya, & Manolis, 2014). With the previously mentioned statistics is very easy to see how students can get distracted during non-engaging lectures.

The Universal design for learning is focused and correlated to three primary brain networks (recognition network, strategic network, and affective network) and their role in the understanding of new material (CAST, 2018; Meyer et al., 2014). The three main

classifications (i.e. Provide Multiple Means of Representation, Provide Multiple Means of Action and Expression, and Provide Multiple Means of Engagement) are internally subdivided into 3 major categories for accessing, building and internalizing the concepts for the benefit of all learners (Cast, 2018; Meyer et al., 2014).

2.1.2 UDL Framework Implementation and Studies

UDL has been thoroughly used and investigated in school classrooms with learning disabled students with overall successful outcomes (Coyne et al., 2012; Gravel, 2017; Marino et al., 2014; Messinger-Willman & Marino, 2010). Marino et al. (2014) applied the UDL guidelines by using virtual games on a middle school science classroom; though no statistical difference was determined, the UDL concepts proved effective in producing higher levels of engagement and satisfaction. In a study done by Lohmann et al. (2018) a set of UDL recommendations were applied on an online teacher preparation course. The authors stated that the implementation was effective, and the participants felt more connected to their teachers and other students in the course.

Applying UDL for the learning disabled has also been researched in universities with positive results. UDL creates learning environments where all learners can be successful regardless of learning style, visible disability, or hidden disability (Parker, 2013). The universal design for learning has a variety of uses and applications including scaffolding social media in online courses (Vie, 2018). Colleges, like the University of New Hampshire, have applied UDL concepts to some courses; stating that they try to add a strategy each time the course is taught to evaluate its effectiveness (Tobin, 2018). Research

by Spooner, Baker, Harris, Ahlgrim-Delzell, and Browder (2007) suggests that introducing UDL in designing a lesson plan in college level courses can make it accessible to all types of students.

The concepts highlighted by UDL can perhaps be used to augment learning in higher education. Higher education students now have technological skills and awareness of digital assistive technology. UDL provides useful guidelines that a course designer can implement to enhance their content when developing courses (CAST, 2018; Meyer et al., 2014). The UDL principles, when followed correctly, will ensure that the student has the options to choose between different modalities of learning, thus enhancing their reception (Bienkowski et al., 2015; Cunningham & Murphy, 2018; Edyburn, 2010; Hollingshead, 2018; Z Kang, Dragoo, Yeagle, & ... 2018; Rogers-Shaw, Carr-Chellman, & Choi, 2018; Rose, 2002)

Enhancing a whole course with the UDL framework is a lengthy process that should be done in small steps (Novak & Rose, 2016). Hence, for this experiment a small sample of slides form an existing aviation course were taken to apply relevant UDL principles and test for effectiveness. Many of the current studies done with UDL focus on qualitative analysis, this research will use statistical analysis and eye tracking software to determine UDL's effectiveness.

This thesis emphasis was on testing the results of applying UDL to higher learning material (i.e. aviation concepts). This was done by measuring several metrics and comparing outputs of the UDL group to the control group (i.e. original, non-enhanced content). Its hypothesized that an improvement in learning will occur when enhancing

higher level contents with UDL principles, thus increasing engagement and interest. Specifically, that eye fixation count, quiz result and eye fixation duration will increase for the UDL materials.

2.1.3 UDL Benchmarking for Feature Implementation

The Table below (Table 1) provides the information gathered from a preliminary UDL feature Benchmarking created to evaluate the possibility of, not only implementing the principles into the experiment but general implementation to provide scaffolding in higher education classroom.

Table 1 UDL features benchmarking summary

FEATURE	WHY?	APPROACHES	PROPOSED IMPLEMENTATION
2.1.3.1 Text to Speech Software UDL Principle: Provide Multiple Means of Representation	This feature provides information in both visual and auditory pathways. It reiterates the information and connects the visual processing to the verbal response. It's a very useful function for students struggling with dyslexia.	-Read words/phrases with adjustable speed (Hall et al, 2012) -Highlight passages and change font: size, and color (Hall et al, 2012)	- Power point provides a text to speech function that can be added to the quick access toolbar. If slides are provided in pdf format - Adobe Acrobat Reader has a "Read Aloud" function in the view bar.
2.1.3.2 Online Text & Word Definition Hyperlink UDL Principle: Provide Multiple Means of Representation	This feature uses multiple visual representations with photos and text. This would reinforce the application of the phrases and, give students an example providing context for better understanding This would prove useful to students who struggle with the meaning of a word and can help clarify misunderstandings.	-Provide definitions and context of words (Hall et al, 2012) -Give translations to other languages for students that don't speak English as a first language (Hall et al, 2012)	-Phraseology can be linked back to the manuals, textbooks or to examples. -Definition of terminology can be scaffolded with images of what the word means. -Offer alternative forms of the same information be it: diagrams, photographs or multimedia.

FEATURE	WHY?	APPROACHES	PROPOSED IMPLEMENTATION
2.1.3.3 Video Examples UDL Principle: Provide Multiple Means of Representation	Videos can be useful to students when trying to explain and perform a task. It gives them the ability to mimic the person in the video and understand the motion they will have to perform. Adding additional videos will give students another medium to connect to the course contents.	- Hall et al. (2012) Provide video examples or photographs of tasks. Teachers in a science classroom found that providing video examples to be a useful tool when explaining science experiments.	-The curriculum contents can feature videos for confusing concepts. - Videos can be created to model multiple ways of problem solving using the previously learned skills. - Videos on platforms such as YouTube, Lynda or similar services could be implemented to scaffold learning
2.1.3.4 Customization of Displays UDL Principle: Provide Multiple Means of Representation	These features help struggling readers select a display or function that can help them to better access and comprehend text. Display adjustability is particularly important for those with vision disabilities.	<u>AEM Explorer:</u> Magnification, text and background color adjustment, customizable layout These features are in accordance to ergonomic practices and ease of access principles.("AEM Explorer," 2018)	-Information of software's as tools for studying the material can benefit students by providing an alternate representation in which the material could be learned.
2.1.3.5 Clarify Vocabulary and Symbols in Learning Material UDL Principle: Provide Multiple Means of Representation	It's important to, not only provide multiple forms of representation, but to also provide clarity and ensure that all learners are able to comprehend lessons and vocabulary without struggling. This can prove beneficial especially in courses with high levels of complexity and where proper terminology is critical	Text-based dictionaries with visual representations and real-world applications (e.g.("Visual Dictionary Online,")) Provide multimedia glossary using hyperlinks within the contents to offer additional information (CAST, 2018)-	- It is beneficial to provide hyperlinks embedded within course content so that students can acquire information when they need it. - Another alternative is to provide a glossary of all relevant terms at the end of the content. - Provide definitions with additional. visual or audio features to improve the clarity of the terms.

FEATURE	WHY?	APPROACHES	PROPOSED IMPLEMENTATION
2.1.3.6 Supplying Background Knowledge UDL Principle: Provide Multiple Means of Representation	It is crucial for students with each learning preference to both understand pre-requisite information and know its relevance to the lesson. New knowledge is more likely to be retained when content is presented in a way that triggers a student's background knowledge.	- Test knowledge of prior lessons before beginning a new lesson - Provide answers and additional information when an online quiz question is answered incorrectly -Create Activities to Activate Background Knowledge: Allow students the chance to illustrate through pictures or writing everything that they already know (CAST, 2018)	- Course materials tend to build on each other. As a new topic is started; encourage students to refresh their memory (via: summary slide, Quiz, Open Questions, etc.) of what has been learned and create an open discussion. This will help them better understand new content, and will provide instructors with a mechanism for gauging how effective the teaching materials have been thus far
2.1.3.7 Questions for Review and Activity Adjusting to Enhance Comprehension UDL Principle: Provide Multiple Means of Action and Expression	Students may struggle to form reflections and responses to the text they read. This is therefore important to confirm comprehension of the reading material. Tools put in place that scaffold understanding of the text and can be used to help students review for exams.	A Text Help toolbar was applied in the classroom to assist students in their reading ability. The toolbar gave students the opportunity to reflect on the text and ensure comprehension. This is used to support reading (Hall et al., 2012	- Providing an extensive review at the end of the presentation or concept studied in the section, is useful to students when they're studying for an exam. - - Include multiple tools of composition when evaluating an activity (e.g. drawing a diagram, writing a description, providing a verbal explanation, etc.). - Use prompts in the presentations to promote reflection about the concepts and processes being learned

FEATURE	WHY?	APPROACHES	PROPOSED IMPLEMENTATION
2.1.3.8 Simulations UDL Principle: Provide Multiple Means of Action and Expression	Simulations give students opportunities to practice the skills they are learning in class. It provides context for the materials as students can see how these concepts are applied. Adding simulations would give students another opportunity to practice and improve problem-solving skills for class assessments.	- Simulations were effective in science classrooms to further represent experiments performed in class. Thus, giving students another chance to practice the procedure and provided a safe way for students to work without supervision. (Hall et al., 2012) - Online simulations gave students the ability to practice new skills. (Hall et al,2012)	A software or simulation that could be run on a student's computer or phone that would allow them to practice outside of class hours would provide additional support for students to really grasp a concept and have fluidity when performing the task. - Informing the students about the university's accessibility options like VPN, Remote desktop connectivity, free software's, etc. as students may not know these options are available
2.1.3.9 Applying Examples and Concepts to Real World Scenarios UDL Principle: Provide Multiple Means of Engagement	Helps students understand the purpose for the things they are studying and learning about during class.	- Students view photographs of the topics they study (Hall et al., 2012) - Students are connected to other websites with relevant information or other useful resources	- Providing context into a real-life scenario or example regarding the concept would give students a familiar case of something they are more likely to see in real life. - Create examples that motivates students by forming an emotional engagement - Make the purpose of a task or exercise preformed explicit so that students can see the relevance and importance.

FEATURE	WHY?	APPROACHES	PROPOSED IMPLEMENTATION
2.1.3.10 Collaborative Feedback and Learner Support UDL Principle: Provide Multiple Means of Engagement	Students can receive feedback on assignments from peers and professors to better understand the ways they can improve their studies This method provides students different ways to approach problem and improves problem-solving skills.	- Providing samples of writing from past students (Hall et al., 2012) - A checklist is used to remind students of items to look for in their draft, such as edits to make, grammar rules, and other writing components - Students post work to collaborative workspace for feedback from peers and professors (e.g.("CAST Science Writer,"))	- Give students opportunities to work together and receive feedback from the instructor while running through scenarios. - Guide students through sequences and prioritization related to the concepts learned. For example: "Pay close attention to the following slide..." - Offer students solutions to manage the information learned. For example: timelines, to-do lists, learning summaries, etc. - Monitor progress by giving low stake assessments this way gathering information of the areas where students are struggling (e.g. Quizzes). - Set learning strategies at the beginning of the lesson. Provided what will be discussed and what are key concepts to be observed.
2.1.3.11 Have a Clearly Defined set of Goals UDL Principle: Provide Multiple Means of Representation, Action and Expression, and Engagement	Educators and learners need to be aware of the intended learning goals so that they can begin to build connections, connect to background knowledge, and practice for expertise. (Cast, 2018) It is important for educators to make learning goals and desired outcomes explicit to the learner so that they can define a target, develop and idea of how to achieve said target and know when this has been achieved.	At all stage's students benefit from being informed of the instructors and institution goals, and their own goals. (Simon, 2009) Having a clear learning goal in mind increases motivation in students and provides a more focused learning session. Our nervous system is driven by clear goals and therefore motivation comes from this. (CAST, 2018)	- Write a slide at the beginning of each presentation that clearly states the key points that the students should master at the end of the lesson. For example: "By the end of this lesson you should be able to understand the following key concepts: …" - Consider providing a learning guide for each week or lesson unit. This guide would outline the specific learning objectives for that week and how they relate to the assignments, specific due dates, additional learning resources, etc. - Goals need to be relevant to students (How are they going to use what is being taught?). Its's important to state why this is the desired goal.

FEATURE	WHY?	APPROACHES	PROPOSED IMPLEMENTATION
2.1.3.12 Provide Multiple: Ways to Solve a Problem, Examples, Counter Examples and Give Numerous Opportunities to Practice UDL Principle: Provide Multiple Means of Representation, Action and Expression	Giving students multiple types of examples helps form patterns of recognition that are useful when the student is solving problems without support. Examples provide support for all learning types and help reinforce methodologies and techniques to solve problems.	Hall et al. (2012) Give students multiple ways to solve a problem Rose and Meyer (2002): Give examples and counterexamples of a problem Give students multiple opportunities to practice a problem so that they can perform the problem automatically on their own	- Adding more examples within the course content, would increase students' ability to recognize different types of problems and develop problem-solving strategies.

2.2 Eye Tracking Background

The earliest experiments of trying to track eye movements began as early as the 1800s (Bergstrom & Schall, 2014). In 1879 Louis Émile Javal noticed how eyes when reading make quick movements(i.e. saccades) and short pauses(i.e. fixations). Edmund Huey built a device at the start of the twentieth century to track eye movements in reading; this could be regarded as the first eye tracker (Huey, 1908). Huey (1908) mentions in his book: "As a beginning of such analysis of reading it seemed important to obtain a definite description of the work of the eye". He fashioned a wearable lens out of plaster to fit the cornea with a small opening and a light lever attached to a pointer that would change positions with eye movement; Holocaine or Cocaine was administered so that no inconvenience was felt. Thankfully, current eye trackers provide researchers with a virtually unobtrusive way to collect vast amounts of data.

Eye tracking technologies have been used in the past for studying visual stimuli, pattern prediction, in the medical field, human factors, consumer behavior, marketing, driving, etc. In the medical field eye tracking has been used to study the scanpaths of specialized experienced doctors to train medical students in diagnosis and treatment (Ashraf et al., 2018; Kok & Jarodzka, 2017). Eye tracking scanpaths have been analyzed similarly in aviation to improve detection of aircraft coalition by analyzing performance data with multiple moving targets from expert air traffic controllers (Ziho Kang & Landry, 2010; Ziho & Landry, 2015). In a recent study Parikh (2017) used eye tracking measures to develop a predictive model(91% accuracy) that evaluates content difficulty for words in real time for e-learning application. Eye tracking data has been used as a measure for

situational awareness in diverse fields like aviation, health services, distracted driving, construction industry, etc.(Hasanzadeh, Esmaeili, & Dodd, 2018; Jeon, 2018; Mayu, Guangyi, & Hiroaki, 2015; Muehlethaler & Knecht, 2016; Williams, Quested, & Cooper, 2013).

Eyes give out a lot of measurable information. Pupil dilation, eye fixation duration and fixation count are some noted types of eye movement measures used to assess visual attention. Eye movements are a response to the vast amounts of visual stimuli . Rosa (2015) did a comprehensive and extensive literature revision on eye tracking origins and methodologies. Around 90% of viewing time is spent in eye fixations; this fixation allow information processing (Rosa, 2015). Saccades are rapid movements in between each of those fixations. The combination of fixations and saccades is known as a scan path.

Fixations account for nearly half of the visual information sent to the brain and it's the only type of vision measurable by eye tracker(Bergstrom & Schall, 2014). The rest of our vision that's not measurable are the parafoveal and peripheral vision. This two are considered residual evolutionary traits and allow the brain to make sense of its surroundings. Fixations interpretation varies depending on the framework of evaluation(Poole & Ball, 2006). Higher fixation duration can indicate greater interest and higher engagement, or it can also be indicative of higher complexity. As Andrew (2007) stated "Fixations naturally correspond to the desire to maintain one's gaze on an object of interest". Pupil dilation has been related to cognitive activity in response to a task(Marshall, 2000). The principle being that the pupil will dilate when a cognitive stimulus engages the subject. Evaluating the relationship of pupil dilation as a measure of cognitive activity is

the foundation of Kahneman's theory of attention (Kahneman, 1973). Pupil responses can have many explanations that depend on the frame of reference in which they are being analyzed, it's is hard to tell whether the dilation is a measure of interest and stimulation or anxiety(Fong, 2012). Therefore, combining eye tracking with additional measures will help better understand experimental results and interpret data depending on the context. A summary table of definitions is provided in Table 2 refer only to relevant metrics that are mentioned or analyzed in this thesis.

Table 2 Eye movements definitions and measures

Eye movements	Definitions	Measures
Fixation	The period of time when the retina is stabilized over an object of interest and new information is acquired from the visual array(Andrew, 2007; Rayner, 2009)	Fixation Duration Fixation Count
Pupillary response	The contraction of the pupil in response to light entering the eye (Merriam-Webster)	Pupil Diameter
Scanpath	The eye movement pattern. It is a combination of fixation and saccades in the order which they were generated.	Scanpath length Scanpath similarity
Saccade	Movements themselves. Usually, we do not obtain new visual information during saccades (Rayner, 2009)	N/A

CHAPTER 3: Problem Scope and Contribution

Studies done for testing UDL effectiveness with physiological responses such as eye tracking data were not found when researching existing literature for this thesis. This thesis will research how we can use the UDL methodology to scaffold pedagogy in a university level and higher education environment. Eye tracking measures will be used to analyze and reach conclusions about how UDL can be beneficial to post-secondary education. The effectiveness of applying this method will be measured by comparing data from a control group with the UDL group results obtained from the experiment (i.e. eye tracking data and quiz results). Findings and literature from this thesis are expected to provide a look into what UDL has to offer and how we can possibly improve higher education teaching by implementing its methodologies.

CHAPTER 4: Methodology

4.1 Participants

Thirty-six participants (Age mean: 25.5 years, Age S.D.: 6.6 years) were recruited from the University of Oklahoma, Gallogly College of Engineering. The study consisted of two groups: Original contents (control group) and UDL contents (treatment group). Participants were randomly assigned to either the controlled group(Original) or the treatment group (UDL), upon agreement of participation in the study. Of the thirty-six participants 18 belonged to the treatment group and 18 to the control group. The control group reviewed digitally (i.e. via PowerPoint) a set of original learning content used by the FAA(Federal Aviation Administration). The treatment group received the same set of slide content but with UDL principles applied to them. Eye measurements, hard copy quiz and brief exit survey administered to both groups.

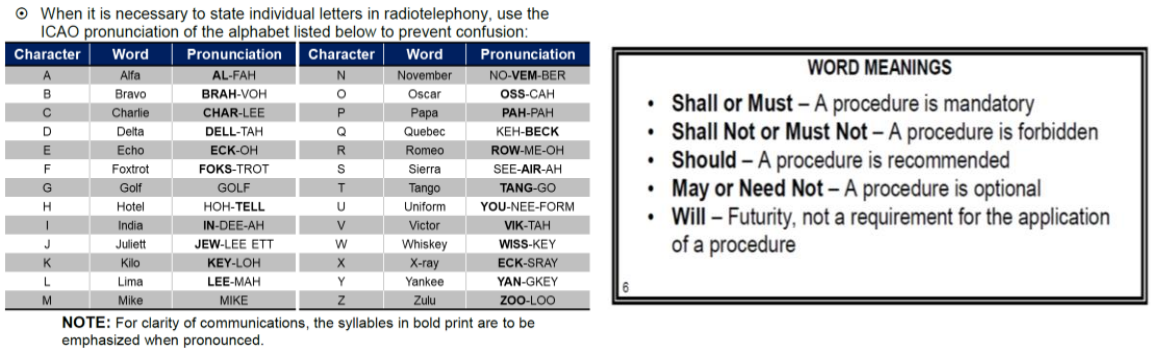
4.2 Apparatus

The experiment was conducted with the use of the Tobii Studio software and Tobii Pro TX300 eye tracker. The Tobii Studio software was used to assemble the experiment including instructions for the participants on how to navigate through the experiment successfully before starting the slide sets. Tobii Pro TX300 eye tracker used to gather the eye movements of the subjects whilst going through every step in the experiment process. The Tobii Studio software was also used to export the eye movement data (eye fixation duration, count and pupil size) collected from each participant and gather descriptive statistics. A quiz was given to the participants in hard copy to test them on the learned

material. MS Office PowerPoint was used to create the slide content for both the original and UDL-inspired slides presented to the participants.

4.3 Scenarios

Participants were recruited by expressing interest in investigating the effects of applying UDL principles to material contents in higher education. The participants were randomly assigned either to the UDL or Original group. Each of the groups went through the same two topics (Topic 1- Standardization in Basic Communication and Topic 2- Radar Arrival and Departures). The topics used were based on an aviation coursework for Air Traffic Controlling. These topics are not taught in engineering which is where most of our subjects' educational background resides; mitigating the effect of previews knowledge in the experiment. However, the topic chosen are basic in aviation knowledge and could be learned by searching the internet or if the subject had previous familiarity with aviation. Examples of the differences from the UDL inspired contents and the Original contents in the slide sets are provided in Figure 2,Figure 3, Figure 4, Figure 5 and Figure 6. Additional examples that highlight the specific representations applied can be found in Appendix B.



When it is necessary to state individual letters in radiotelephony, use the ICAO pronunciation of the alphabet listed below to prevent confusion:

Character	Word	Pronunciation	Character	Word	Pronunciation
A	Alfa	**AL**-FAH	N	November	NO-**VEM**-BER
B	Bravo	**BRAH**-VOH	O	Oscar	**OSS**-CAH
C	Charlie	**CHAR**-LEE	P	Papa	**PAH**-PAH
D	Delta	**DELL**-TAH	Q	Quebec	KEH-**BECK**
E	Echo	**ECK**-OH	R	Romeo	**ROW**-ME-OH
F	Foxtrot	**FOKS**-TROT	S	Sierra	SEE-**AIR**-AH
G	Golf	GOLF	T	Tango	**TANG**-GO
H	Hotel	HOH-**TELL**	U	Uniform	**YOU**-NEE-FORM
I	India	**IN**-DEE-AH	V	Victor	**VIK**-TAH
J	Juliett	**JEW**-LEE ETT	W	Whiskey	**WISS**-KEY
K	Kilo	**KEY**-LOH	X	X-ray	**ECK**-SRAY
L	Lima	**LEE**-MAH	Y	Yankee	**YAN**-GKEY
M	Mike	MIKE	Z	Zulu	**ZOO**-LOO

NOTE: For clarity of communications, the syllables in bold print are to be emphasized when pronounced.

WORD MEANINGS

- **Shall or Must** – A procedure is mandatory
- **Shall Not or Must Not** – A procedure is forbidden
- **Should** – A procedure is recommended
- **May or Need Not** – A procedure is optional
- **Will** – Futurity, not a requirement for the application of a procedure

6

Figure 2. Example of original contents for Topic 1-Standardization in Basic Communication

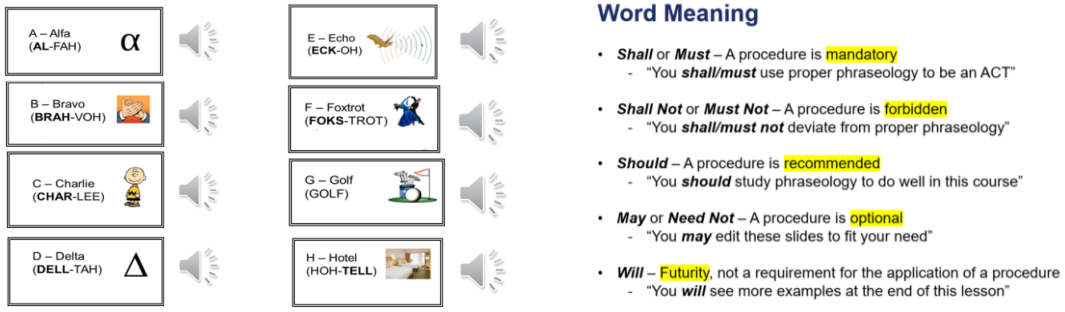
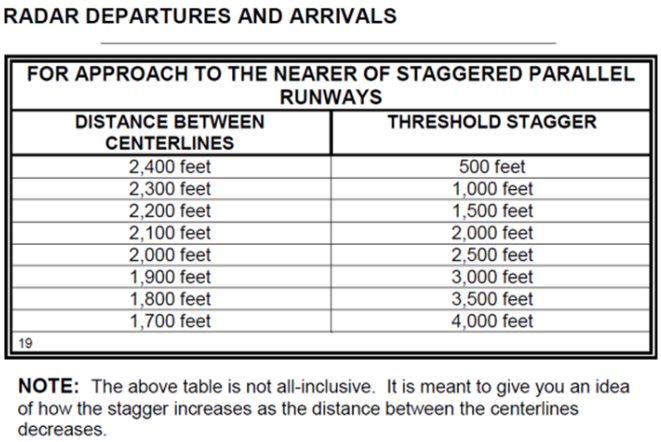


Figure 3. Example of modified UDL inspired contents for Topic 1-Standardization in Basic Communication- The following UDL principles were applied : provide additional visual guidelines, provide audio/ text to speech, provide real life specific examples and highlight key concepts.



RADAR DEPARTURES AND ARRIVALS

FOR APPROACH TO THE NEARER OF STAGGERED PARALLEL RUNWAYS	
DISTANCE BETWEEN CENTERLINES	**THRESHOLD STAGGER**
2,400 feet	500 feet
2,300 feet	1,000 feet
2,200 feet	1,500 feet
2,100 feet	2,000 feet
2,000 feet	2,500 feet
1,900 feet	3,000 feet
1,800 feet	3,500 feet
1,700 feet	4,000 feet

19

NOTE: The above table is not all-inclusive. It is meant to give you an idea of how the stagger increases as the distance between the centerlines decreases.

Figure 4. Example of original contents for Topic 2-Radar Departures and Arrivals(IFR)

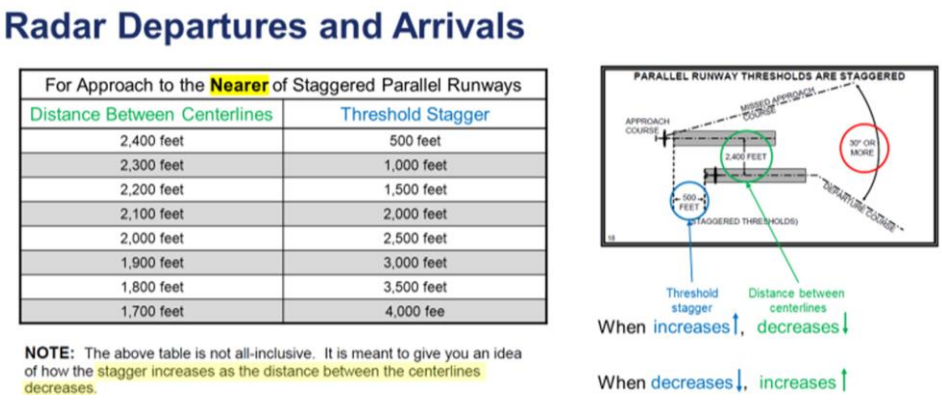


Figure 5. Example of modified UDL inspired contents Topic 2- Radar Departures and Arrivals(IFR) - The following UDL principles were applied: provide additional visual guidance, highlight key concepts, make relationship between elements explicit and revisit key ideas

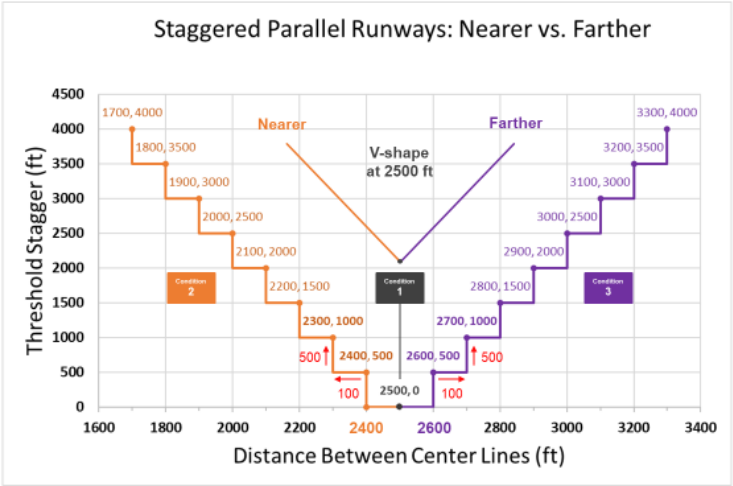


Figure 6. Example of modified UDL inspired contents Topic 2- Radar Departures and Arrivals(IFR) – Additional slide demonstration inverse relationship of the nearer and farther runways in relation to threshold stagger and the distance between the center lines

4.4 Tasks and Procedure

Upon arrival participants were randomly assigned either to the UDL or the Original group. Participants were not informed of which of the groups they were assigned. After calibrating the eye tracker with the participants eye movements, participants followed the prompts given by the system to carry out the learning section of the experiment. Both groups (UDL and Original) received the same prompts by the system and had the same maximum amount of time to study the contents. They were given a maximum of 8 minutes to go through the first set of slides (Topic 1- Standardization in Basic Communication). After this, they were given 12 minutes to learn the second set of slides (Topic 2- Radar Arrival and Departure (IFR)). Upon learning the contents for each topic and exiting the eye tracking system, the participants had to perform a masking activity (build a paper airplane) for a maximum of 5 minutes. This was done to mitigate the effect of short-term learning when providing quiz answers (participants were not aware that the exercise was a masking activity). Subsequently participants were given a quiz of the learned topics and asked to answer it to the best of their ability. The quiz consisted of open short answers; an example of the quiz format can be found in Appendix A. The quiz was given for a maximum of 15 minutes. A brief optional survey was also conducted at the end of this experiment regarding satisfaction, previous familiarity with given topics, age and education level.

4.5 Measurements

The measures gathered and analyzed for this experiment were: Eye Fixation Duration, Eye Fixation Count, Average Pupil Size and Quiz Scores. Eye Fixation Duration, Eye

Fixation Count and Average Pupil Size are recorded by subject on the Tobii Pro TX300. Quiz Scores were manually graded with a double verification for correctness (two graders). Each of the parts within the topics had a total of 50 points each. The two topics and parts within the topics were individually tallied and each given corresponding percentages based on correct answers given.

4.6 Data Analysis

To measure the time spent on the topics per parts, areas of interest (AOIs) were defined using the Tobii Studio software. The defined AOI's for Topic 1-Standardizing Basic Communication were grouped by either: Part 1-Alphabet Pronunciation and Part 2-Word Meaning. Similarly, AOIs for Topic 2-Radar Arrival and Departure(IFR) were grouped under each part: Part 1-Figure Comprehension, and Part 2-Trend Understanding. The eye fixation duration, eye fixation count and pupil size of the participants calculated by the software was exported for analysis using descriptive and inferential statistics. The Quiz grading was out of a 100pts total for each topic (i.e. Topic 1-Standardizing Basic Communication and Topic 2-Radar Arrival and Departure(IFR)). After grading the quiz, de-identified scores were analyzed using SAS Software. Normality for all analyzed data was checked using the Shapiro-Wilks test. Based on these results parametric t-test were applied for fixation duration and fixation count in topics: Topic2.Part1 and Topic2.Part 2; for average pupil size normality was found for Topic1.Part1, Topic1.Part 2 and Topic2.Part 2. The non-parametric test Mann-Whitney U (Wilcoxon rank sum test) was applied for all quiz result topics, for fixation duration and count (Topic1.Part 1 and Topic1.Part 2) and

finally for average pupil size in Topic2.Part1. A one tailed p-value was considered for non-normal distributions; we hypothesized and are interested in a positive difference for the UDL participants. The p-value corresponding to students t-distribution corresponds to a 2 tailed probability.

CHAPTER 5: Results and Discussion

5.1 Experimental Results

. Eye fixations durations, eye fixation count and pupil size for each participant were recorded throughout the experiment. This data was subsequently analyzed for differences in the UDL and Original group. For the case of *Topic1.Part1-Alphabet Pronunciation* the eye fixation duration means, standard deviation and standard error were $\bar{X}$=132s S.D.=53s S.E.=12s for UDL, and $\bar{X}$=120s S.D.=86s S.E.=20s for Original. *Topic1.Part2- Word Meanings* had a mean standard deviation and standard error of $\bar{X}$=56s S.D.=28s S.E.=7s for UDL, and $\bar{X}$=66s S.D.=37s S.E.=9s for Original. The plots showing the means and standard error for each of the subtopics of *Topic 1* can be found in Figure 7. For *Topic2.Part1- Figure Comprehension* the eye fixation duration means, standard deviation and standard error were $\bar{X}$=173s S=69s S.E.=16s for UDL and $\bar{X}$=168s S.D.=90s S.E.=21s for Original. Additionally, *Topic2.Part2- Trend Understanding* eye fixation duration mean standard deviation and standard error were $\bar{X}$=66s S.D.=29s S.E.=7s for UDL, and $\bar{X}$=42s S.D.=34s S.E.=8s for Original. The plots showing the means and standard error for each of the subtopic of Topic 2 can be found in Figure 8

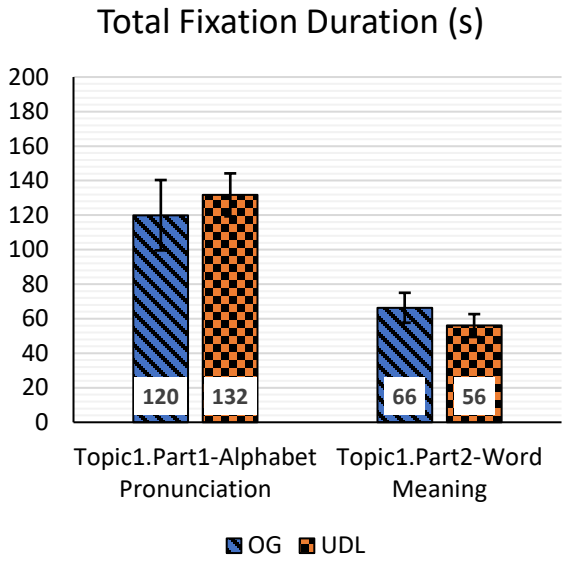


Figure 7. Eye Fixation duration – Boxplots for each subtopic of Topic 1-Standardization in Basic Communication for Original and UDL groups.

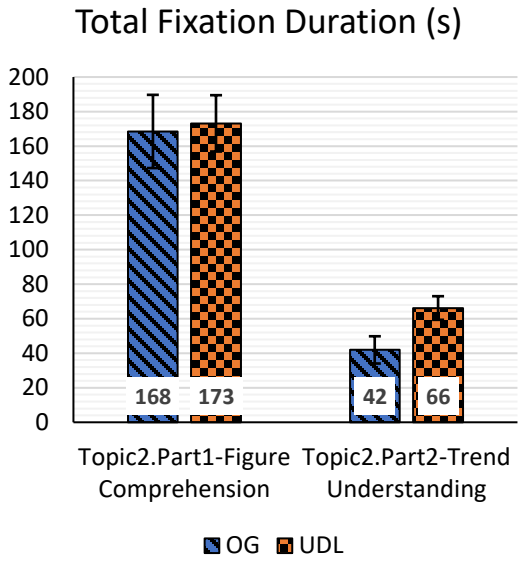


Figure 8. Eye Fixation duration - Boxplots for each subtopic of Topic 2-Radar Arrival and Departure (IFR) for Original and UDL groups.

Table 3 summarizes the results of the p-values obtained for each of the topics where eye fixation duration was evaluated. Significance was found for Topic 1 (Basic Communication)- Part1 (Alphabet Pronunciation) and Topic 2 (IFR)- Part 2 (Trend Understanding).

Table 3 Eye Fixation Duration Results- P-values and Statistic of Topics when comparing Original contents to UDL

Topic Breakdown	*p-value*	*Statistic*
Topic 1 (Basic Communication)- Part1 (Alphabet Pronunciation)- Wilcoxon	0.0254	395
Topic 1 (Basic Communication)- Part2 (Word Meaning) -Wilcoxon	0.2606	312
Topic2(IFR)- Part1 (Figure Comprehension)- T-test	0.86	-0.18
Topic 2 (IFR)- Part 2 (Trend Understanding)- T-test	0.0263	-2.32

Eye fixation count was also analyzed per Topics in the experiment for significant differences between the UDL and Original group. In terms of descriptive statistics, *Topic1.Part1-Alphabet Pronunciation* had eye fixation count means, standard deviation and standard error of $\bar{X}$=593 S.D.=177 S.E.=42 for UDL, and $\bar{X}$=488 S.D.=316 S.E.=74 for Original. *Topic1.Part2- Word Meanings* had a mean standard deviation and standard error of $\bar{X}$=273 S.D.=112 S.E.=26 for UDL, and $\bar{X}$=307 S.D.=178 S.E.=42 for Original. The plots showing the means and standard error for each of the subtopics of *Topic 1* can be found in Figure 9

For *Topic2.Part1- Figure Comprehension* the eye fixation count mean, standard deviation and standard error were $\bar{X}$=840 S.D.=288 S.E.=68 for UDL and $\bar{X}$=812 S.D.=429 S.E.=101 for Original. Additionally, *Topic2.Part2- Trend Understanding* eye fixation count mean, standard deviation and standard error were $\bar{X}$=310 S.D.=110 S.E.=26 for UDL, and $\bar{X}$=196 S=148 S.E.=35 for Original. Plots showing the means and standard error for each of the subtopic of Topic 2 can be found in Figure 10.

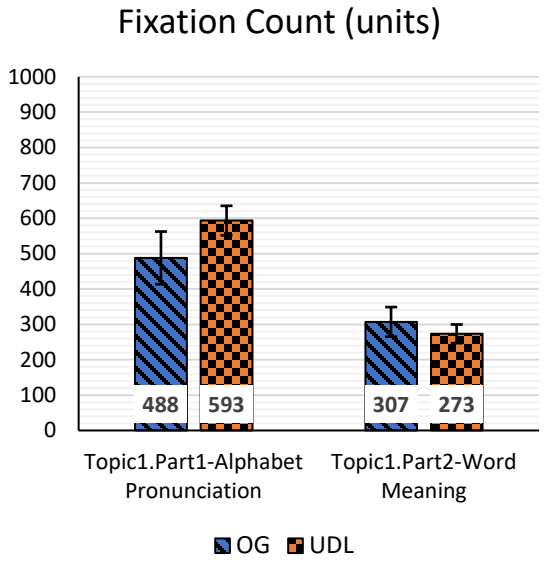


Figure 9. Eye Fixation Count – Boxplots for each subtopic of Topic 1-Standardization in Basic Communication for Original and UDL groups.

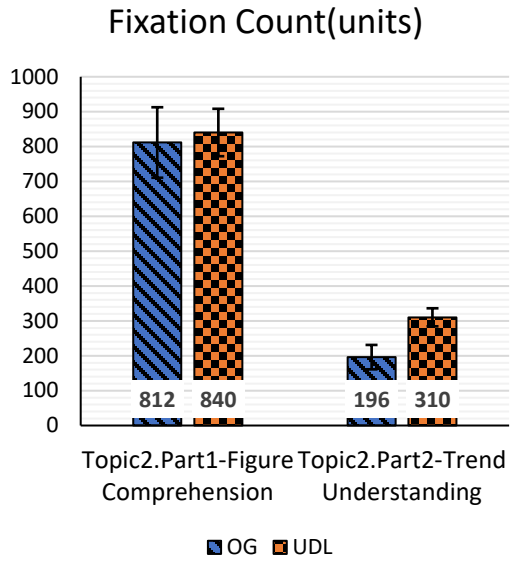


Figure 10. Eye Fixation Count - Boxplots for each subtopic of Topic 2-Radar Arrival and Departure (IFR) for Original and UDL groups.

The table below (Table 4) depicts the p-values for the eye fixation counts in each of the topics analyzed. In concurrence with eye fixation duration results Topic 1 (Basic Communication)- Part1 (Alphabet Pronunciation) and Topic 2 (IFR)- Part 2 (Trend Understanding) were also found to be significant for eye fixation count.

Table 4 Eye Fixation Count Results- P-values and Statistic of Topics when comparing Original contents to UDL

Topic Breakdown	**p-value**	**Statistic**
Topic 1 (Basic Communication)- Part1 (Alphabet Pronunciation)-Wilcoxon	0.0096	406.5
Topic 1 (Basic Communication)- Part2 (Word Meaning) -Wilcoxon	0.46	330
Topic2(IFR)- Part1 (Figure Comprehension)- T-test	0.81	-0.23
Topic 2 (IFR)- Part 2 (Trend Understanding)- T-test	0.0129	-2.62

Pupil size was averaged (i.e. Left pupil and Right pupil) per participant and was subsequently analyzed per *Topics* in the experiment for significant differences between the UDL and Original group. *Topic1.Part1-Alphabet Pronunciation* had pupil size means, standard deviation and standard error of $\bar{X}$=3.11mm S.D.=0.51mm S.E.=0.12mm for UDL, and $\bar{X}$=3.04mm S.D.=0.36mm S.E.=0.08mm for Original. *Topic1.Part2- Word Meanings* had a mean standard deviation and standard error of $\bar{X}$=2.99mm S.D.=0.47mm S.E.=0.11mm for UDL, and $\bar{X}$=2.94mm S.D.=0.34mm S.E.=0.08mm for Original. The plots showing the means and standard error for each of the subtopics of *Topic 1* can be found in Figure 11. In *Topic2.Part1- Figure Comprehension* the pupil size mean, standard deviation, and standard error were $\bar{X}$=2.97mm S.D.=0.49mm S.E.=0.12mm for UDL and $\bar{X}$=2.93mm S.D.=0.30mm S.E.=0.07mm for Original. Additionally, *Topic2.Part2- Trend Understanding* pupil size mean, standard deviation and standard error were $\bar{X}$=2.99mm S.D.=0.50mm S.E.=0.12mm for UDL, and $\bar{X}$=3.03mm S.D.=0.35mm S.E.=0.08mm for Original. The plots showing the means and standard error for each of the subtopic of Topic 2 can be found in Figure 12**.**

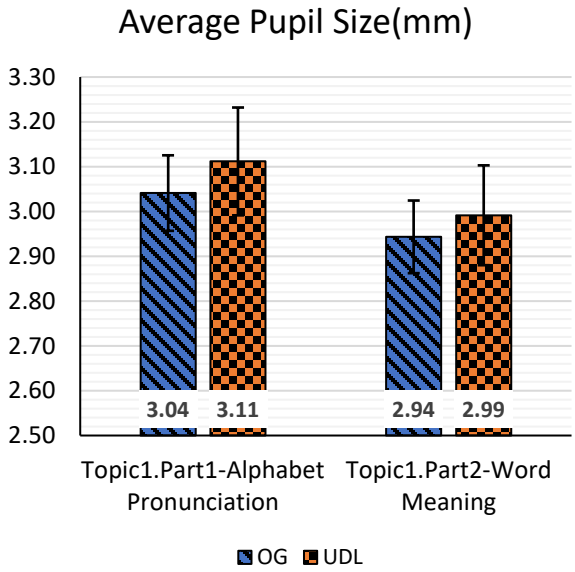


Figure 11. Pupil Size – Boxplots for each subtopic of Topic 1-Standardization in Basic Communication for Original and UDL groups.

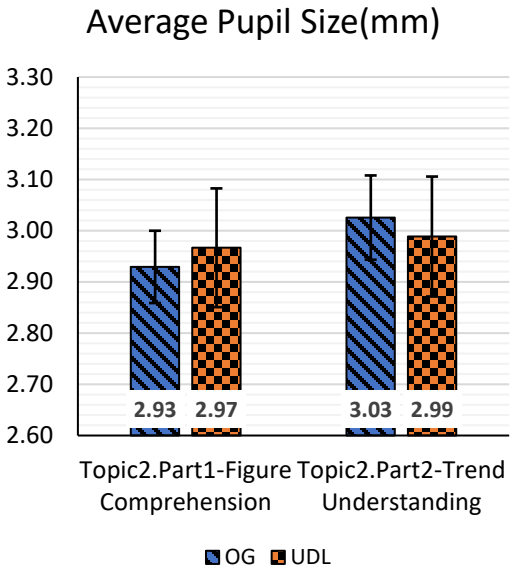


Figure 12. Pupil Size - Boxplots for each subtopic of Topic 2-Radar Arrival and Departure (IFR) for Original and UDL groups.

In Table 5 the p-value outputs for the average pupil size are portrayed. No difference was found in pupil size. It's worth noting that although no significance was found, mean values obtained from the descriptive statistics tended to be slightly higher for UDL participants.

Table 5 Pupil Size Results- P-values and Statistic of Topics when comparing Original contents to UDL

Topic Breakdown	*p-value*	*Statistic*
Topic 1 (Basic Communication)- Part1 (Alphabet Pronunciation)-Wilcoxon	0.63	-0.48
Topic 1 (Basic Communication)- Part2 (Word Meaning) -Wilcoxon	0.73	-0.35
Topic2(IFR)- Part1 (Figure Comprehension)- T-test	0.35	345
Topic 2 (IFR)- Part 2 (Trend Understanding)- T-test	0.8	0.26

Scanning patterns for examples of original content versus UDL inspired contents are provided below in Figure 13 and Figure 14. The blue(Original Contents) and orange(UDL Content) circles in the figures represent the eye fixations, the size of the circle determines the duration of said fixation and the number the sequence of the fixations. These fixations are connected by a line (i.e. saccades) that link the fixations. From the scanpaths observed in Figure 13 and Figure 14 we can easily perceive the increase in eye fixation count and durations for the UDL inspired contents when compared to the Original.

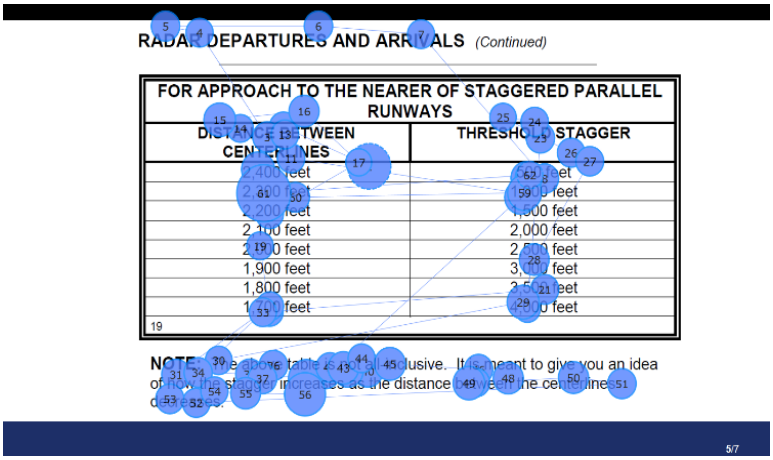


Figure 13. Scanpath Example Original Contents- Eye movements and fixations are space, occurring only on some data points.

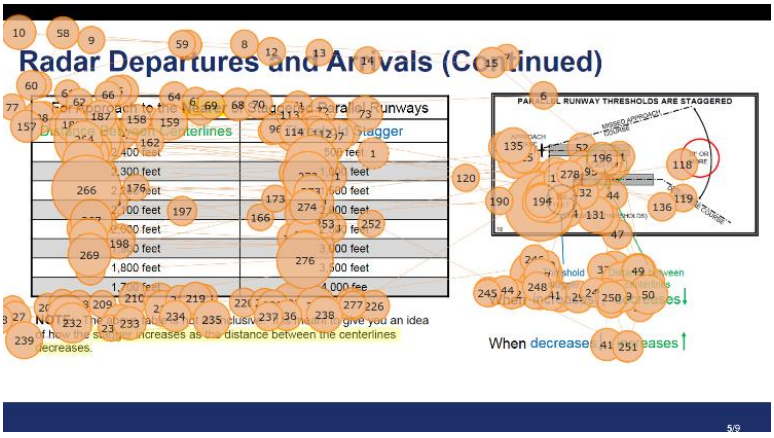


Figure 14. Scanpath Example UDL Contents- Eye fixations cover most of the data provided. Eye fixation transitions show active reading behavior.

The Quiz administered to the participants tested their knowledge on *Topic 1- Standardization in Basic Communication* and *Topic 2- Radar Departures and Arrival(IFR)*. The questions were formulated as such that any subject would be able to answer them correctly regardless of the treatment received (Original, UDL). Each part for the administered topics was evaluated individually. Figure 15 demonstrates the results for *Topic1.Part1-Alphabet Pronunciation* and Figure 16 the results for *Topic1.Part2-Word Meaning*. The resulting means, standard deviation and standard error in *Topic1.Part1-Alphabet Pronunciation* were: $\bar{X} = 19.2 \;\; \mathrm{S} = 18.2 \;\; \mathrm{S.E.} = 4.3$ for Original content, and $\bar{X} = 25.2 \; \mathrm{S} = 16.1 \; \mathrm{S.E.} = 3.8$ for UDL inspired content. The means, standard deviation and standard error for *Topic1.Part2-Word Meaning* were: $\bar{X} = 32.4 \;\; \mathrm{S} = 9.0 \;\; \mathrm{S.E.} = 2.1$ for Original content and $\bar{X} = 37.0 \; \mathrm{S} = 6.5 \; \mathrm{S.E.} = 1.5$ for UDL inspired content.

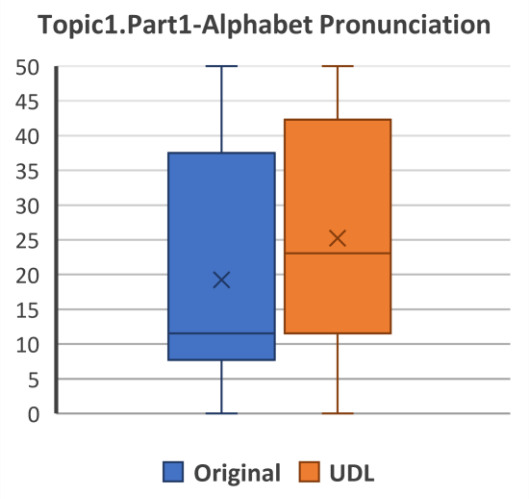


Figure 15. Quiz results- Box plots for Topic1.Part1- Alphabet Pronunciation

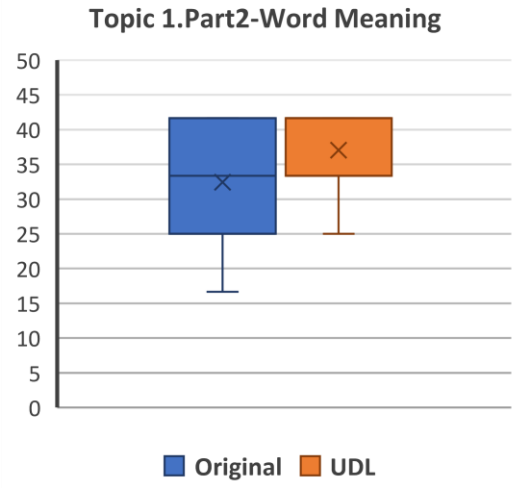


Figure 16. Quiz results- Box plots for Topic1.Part2-Word Meaning

Figure 17 and Figure 18 portray the Boxplots of Topic2.Part1-Figure Comprehension and Topic2.Part2-Trend Understanding. The means, standard deviation and standard error for Topic2.Part1-Figure Comprehension were $\bar{X} = 28.1 \quad S = 20.3 \; S.E. = 4.8$ for Original content and $\bar{X} = 42.7 \quad S = 9.2 \quad S.E. = 2.2$ for UDL inspired content. Topic2.Part2-Trend Understanding yields a $\bar{X} = 34.7 \quad S = 16.9 \; S.E. = 4.0$ for Original content and $\bar{X} = 43.8 \; S = 10.7 \; S.E. = 2.5$ for UDL inspired content.

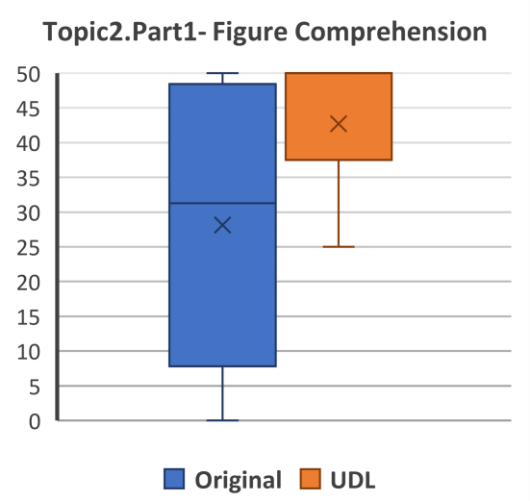


Figure 17. Quiz results- Box plots for Topic2.Part1- Figure Comprehension

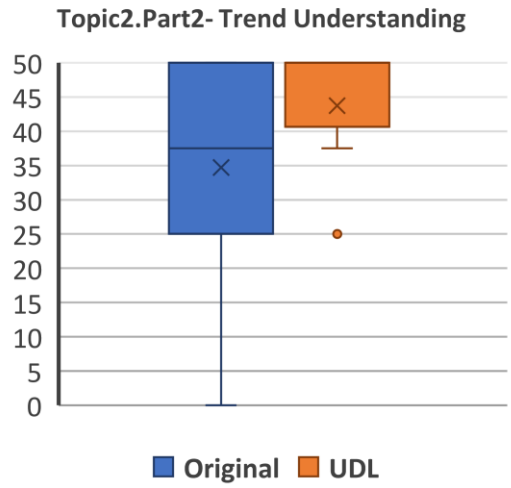


Figure 18. Quiz results- Box plots for Topic2.Part2- Trend Understanding

Table 6 shows the summarized p-value results for each of the parts within the topics. Additionally, it portrays the corresponding S Statistic per topic and part. From the table we can note that significance was found for Topic 2 (IFR)- Part 1 (Figure Comprehension). Marginal significance was found for: Topic 2 (IFR)- Part 2 (Trend Understanding) and Topic 1 (Basic Communication)- Part2 (Word Meaning).

Table 6 Quiz Results- P-values and S Statistic of Topics when comparing Original contents to UDL

Topic Breakdown	**p-value**	**Statistic S**
Topic 1 (Basic Communication)- Part1 (Alphabet Pronunciation)	0.1162	295
Topic 1 (Basic Communication)- Part2 (Word Meaning)	0.0647	286
Topic 2 (IFR)- Part 1 (Figure Comprehension)	0.0141	266.5
Topic 2 (IFR)- Part 2 (Trend Understanding)	0.0502	284

5.2 Discussion

Data showed that introducing the UDL principles to the learning material increased eye fixation duration. A greater fixation duration is interpreted to the participants focusing and engaging for longer time periods in the areas of interest. This concurs with the eye fixation count results, where counts were generally greater for the UDL participants. For both eye fixation duration and fixation count the means observed were higher for the UDL participant in three of the four topics evaluated. Standard errors were also consistently lower for UDL throughout all topics. Significance was found for both the eye fixation duration and count for Topic 1 (Basic Communication)- Part1 (Alphabet Pronunciation) and Topic 2 (IFR)- Part 2 (Trend Understanding). It's important to highlight that these two topics are also where the majority of the UDL principles were applied. For example, in Figure 6 the trends and steps are clearly visible enabling the students to better understand and internalize the contents. We can interpret this significance as possible increased interest from the participant in relation to the topic.

In Figure 13 and Figure 14 an example shows how the scanpath pattern between UDL and Original content differs greatly. When observing the pattern of the original contents there are noticeable areas when participants appears to skip and skim over the contents. There are short eye fixation durations and very few eye fixation counts. Whereas, when UDL contents are applied, there is thorough reading on behalf of the participant. The scanpath shows back and forth eye movements between the table and figure. We could stipulate from this that the subject was using all the means of representation provided to grasp the concept. Additionally, the participant is using all elements in the slide and cross

examining to understand how they relate. There is significantly denser pattern observed in the UDL example scanpath, this indicative of a very high level of engagement.

Significance was not able to be determined for the averaged pupil size. However, pupil size was slightly larger for UDL participants in three out of the four topics; dilated pupil in this study is interpreted as an increase in engagement.

Quiz Data Analysis showed a consistently higher mean, lower standard deviation and lower standard error for participants that received the UDL inspired contents for every question and topic. Therefore, the slides enhanced with UDL consistently produced a higher overall performance in the Quiz. Figure 15, Figure 16, Figure 17 and Figure 18 represent this in a highly visual format; the spread (deviation) in the boxplots for UDL is consistently lower than that of the Original, the X (Mean) is consistently higher for UDL. Additionally, note how the 50% of the sample population line (median) for UDL is significantly higher than that of the Original. Once again, indicating that when implementing UDL the sampled population had consistently better results.

A summary provided in Table 6 contains the corresponding p-values, and S-statistic for the topics and parts provided in the quiz. As expected, for Topic2. Part1-Figure comprehension yielded significant differences between using UDL enhanced material vs Original content material. For Topic 1. Part2-Word Meaning and Topic 2. Part2-Trend Understanding results showed marginal difference with a p-value of 0.0647 and 0.0502, respectively. Therefore, we stipulate that with a larger data set significance would be found. For Topic1.Part1-Alphabet Pronunciation a p-value of p=0.116 was obtained. A possible reason we were not able to determine significance can be due to some of the Original

content's subjects being extremely familiar with the topic, and thus creating outliers in the data. It's worth noting that when excluding subjects that identified themselves as 'very familiar' with Topic 1.1 from both the UDL and Original quiz results, a significance is obtained in favor of UDL*(p=0.035).* Thus, it can be inferred that a larger dataset or exclusion of outliers can produce significance for this topic.

In a small survey conducted at the end of the experiment the participants that received the enhanced contents had a higher level of satisfaction that those who did not. For example the participants were asked if the slides stimulated their interest in the given topics 61% of participants given UDL slides strongly agreed or agreed with this statement, compared to only 17% of participants given the original materials. . Participants were also asked if the slides were easy to understand; 83% of the UDL group agreed compared to 56% in the Original group. When asked if the slides were effective in highlighting the main concepts 94% of UDL participants either agreed or strongly agreed, whereas only 50% of the Original content participants agreed. Finally when asked if they would have benefitted from additional examples an overwhelming 83% that received the Original contents agreed compared to only 28% of UDL participants. UDL participants unanimously agreed, when asked in a separate set of questions designed specifically for them, that concepts like audio clips, highlighting key materials, dividing the information in "Chunks", use of colors to differentiate concepts, revisiting concepts via graphs, texts and side by side comparisons facilitated their understanding of the material.

It's important to note that the concepts chosen for this experiment were from an existing aviation course and that the slides are not inherently bad at displaying the contents. The

original materials are not displayed in an inconvenient format. For example in Figure 2 and Figure 4 you can see how the original contents are formatted in a table; tables are excellent ways to summarize information. However, they are not the only way to display information or stimulate learning and can benefit from additional examples and representation of the materials.

This research used statistical analysis of eye tracking software, quiz results and with a brief exit survey to determine UDL's effectiveness. Similar to Marino et al. (2014), UDL participants expressed higher levels of satisfaction when asked about the contents given and were more interested in the topics by the end of the experiment. Based on the reviewed literature and the experimental results highlighted in this thesis it is evident there is a positive impact when applying UDL to learning materials in higher education. Therefore, when designing or updating courses it's important to consider ways in which the contents can improve by applying methods like the UDL framework.

CHAPTER 6: Limitations and Future Research

The current study only considered the overall effect of the all the UDL principles applied to the slides. The effectiveness of each individual UDL principle was not investigated. Continuing the investigation of the effect of each UDL principle is important; some might be more effective that others, whereas some may yield no effect. This would allow us to determine the effect of each of the applied UDL principles on learning. This UDL implementation experiment was tested on aviation topics, thus investigating how the UDL contents work throughout different topics in higher education should be considered. Additional eye movement measures can be evaluated, like investigating movement transitions (i.e. saccades) to analyze for visual entropy.

Certain confounding effects could later be mitigated when statistically analyzing this type data. For example: having previous knowledge of the material, English as a first language, and the participants level of education. Experiment participants with significant prior knowledge of Topic1-Part1 were identified for the Original content group (2 participants). Demographic data collected showed that a higher percentage of people (19%) that took the Original contents were pursuing higher education (master's and doctorates). Although post-hoc testing determined no significant effect from the previously mentioned, balancing of the data could ensure that no additional factors influence the results. Performing a brief demographic survey before the experiment can be used to better distribute participants between the groups, thus mitigating any effect. For posterity, performing the experiment on a larger sample size can better define results that were determined as marginally significant. Having a larger sample size also has the potential to

normalize the data so that additional analysis could be performed (e.g. MANOVA Analysis).

Combining UDL with other learning methods can also be investigated. Measuring situational interest after applying the UDL methods to higher learning could yield promising results as both methods focus on enhancing contents to stimulate learning. Some brief insight into situational interest is described below.

6.1 Situational Interest

Situational Interest can be defined as "focused attention and an affective reaction that is triggered in the moment by environmental stimuli, which may or may not last over time" (S Hidi & Renninger, 2006; Rotgans & Schmidt, 2011). Research that has focused on interest in a learning environment has tried to capture what characteristics spark interest in individuals (Suzanne Hidi, 1990; Krapp, Hidi, & Renninger, 1992). Individual interest is stable in the individual; however, situational interest are influenced and generated by stimulus (Krapp et al., 1992). This can mean that situational interest can be manipulated, enhanced by a change in the environment evaluated. For reading English literature interest in the information has been suggested to require less effort (Suzanne Hidi, 1990). Rotgans and Schmidt (2014) argued in their study that prior knowledge determines the extent of situational interest; concluding that there needs to be a gap into the known and the unknown to stimulate situational interest. In Chen, Darst, and Pangrazi (2001) they evaluated situational interest with five dimensional sources: novelty, challenge, attention, demand, exploration intention and instant enjoyment. They experiment was conducted in physical education on 472

middle school students and used a situational interest scale (Chen, Darst, & Pangrazi, 1999). The data was gathered via a survey of 24 items and they were evaluated using a 5-point Likert scale to measure levels of student feelings about the activity Their results found that total interest highly correlates to the feeling of enjoyment the activity generates (Chen et al., 2001).

Not unlike UDL, situational interest under the instructor's control and can be manipulated by the material given. Situational interest measures could be used to determine if the UDL framework increases students' feeling of enjoyment and engagement based on how the material is presented to them. Now, more than ever, there is a necessity for employing techniques that will still motivate the student to interact and regulate their learning with limited supervision. Courses now days are at least partially online. Professors use slides to scaffold their teachings and universities have platforms like canvas to post class contents, give quizzes, etc. It is important to keep investigating and combine techniques from multiple fields like psychology, human factors, education, science, etc. to enhance interest in learning for todays absent-minded learner.

CHAPTER 7: Conclusion

Overall experiment results showed favorable outcomes when applying UDL. Subjects tended to be more thorough in their scan pattern when given UDL inspired contents; whereas, subjects in the original contents tended to skim over the material. The means of quiz results for UDL were higher and yielded smaller standard deviations when compared to the Original content participants. Engagement with the contents (i.e. Eye fixation count, eye fixation duration) was longer for UDL participants, and satisfaction/interest levels (i.e. survey results) were higher. Therefore, it can be stipulated that adding the principles within the contents had a positive effect for learning and increasing focus for higher education courses. Education classes are generally not required for teaching in higher education. Thus having professors apply UDL to their courses could help students grasp complex concepts and struggle less in comprehending. This in turn has the potential to improve students' grades, attitudes towards learning and readiness when joining the workforce. It can be stipulated that adding the UDL principles a positive effect in learning and shows promise for increasing focus for the average university student.

"Do not confine your children to your own learning, for they were born in another time." (Hebrew Proverb)

"Tell me and I will forget; show me and I may remember; involve me and I will understand"(Xun Kuang,312-230 BC)

"Education is the passport to the future, for tomorrow belongs to those who prepare for it today" (Malcolm X, 1964)

7.1 Key Points

- UDL enhanced contents related to aviation coursework were presented to university level students
- The group given UDL enhanced contents had better quiz results, eye fixation duration and eye fixation count overall.
- No significant difference in pupil dilation was detected among the groups
- The group given UDL enhanced contents thoroughly revised the materials given to them, whereas the group given the original contents glazed over the material presented to them.
- UDL participants expressed higher levels of satisfaction when asked about the contents given and were more interested in the topics by the end of the experiment.

References

AEM Explorer. (2018). Retrieved from http://aem.cast.org/navigating/aim-explorer.html

Andrew, D. (2007). *Eye tracking methodology: theory and practice* (2nd ed. ed.): Germany: Springer Verlag.

Ashraf, H., Sodergren, M. H., Merali, N., Mylonas, G., Singh, H., & Darzi, A. (2018). Eye-tracking technology in medical education: A systematic review. *Medical teacher, 40*(1), 62-69. doi:10.1080/0142159X.2017.1391373

Bergstrom, J., & Schall, A. (2014). *Eye tracking in user experience design*: books.google.com.

Bienkowski, M., Gerard, S. N., Rubin, S., Sanford, C., Murray-Borrelli, D., Driscoll, T., . . . Styles, K. (2015). Ed Tech Developer's Guide: A Primer for Software Developers, Startups, and Entrepreneurs. *Office of Educational Technology, US Department of Education*. Retrieved from https://eric.ed.gov/?id=ED566874

Brockelman, K. F., & Scheyett, A. M. (2015). Faculty Perceptions of Accommodations, Strategies, and Psychiatric Advance Directives for University Students With Mental Illnesses. *Psychiatric Rehabilitation Journal, 38*(4), 342-348. doi:10.1037/prj0000143

CAST. (2018). CAST. Retrieved from http://www.cast.org/

CAST Science Writer. Retrieved from https://sciencewriter.cast.org/welcome;jsessionid=FF6F1E783C58295A2AB17AB3DC162313

Chen, A., Darst, P. W., & Pangrazi, R. P. (1999). What constitutes situational interest? Validating a construct in physical education. *Measurement in physical education and exercise science, 3*. Retrieved from https://shapeamerica.tandfonline.com/doi/abs/10.1207/s15327841mpee0303_3

Chen, A., Darst, P. W., & Pangrazi, R. P. (2001). An examination of situational interest and its sources. *British Journal of Educational Psychology, 71*(3), 383-400. doi:10.1348/000709901158578

Coyne, P., Pisha, B., Dalton, B., Zeph, L. A., & Smith, N. C. (2012). Literacy by Design: A Universal Design for Learning Approach for Students With Significant Intellectual Disabilities. *Remedial and Special Education, 33*(3), 162-172. doi:10.1177/0741932510381651

Cunningham, L., & Murphy, O. (2018). Embracing the Universal Design for Learning Framework in Digital Game Based Learning. *Transforming our World Through …*. Retrieved from https://books.google.com/books?hl=en&lr=&id=grh9DwAAQBAJ&oi=fnd&pg=PA409&dq=embracing+the+universal+design+for+learning+framework+in+digital+game+based+learning&ots=lUABS9ovyg&sig=aflNy-I25-rfpREQE7ectz0-kCw

Deloitte. (2018). *Global Mobile Consumer Survey*. Retrieved from https://www2.deloitte.com/tr/en/pages/technology-media-and-telecommunications/articles/global-mobile-consumer-survey-us-edition.html

Edyburn, D. L. (2010). Would You Recognize Universal Design for Learning if You Saw it? Ten Propositions for New Directions for the Second Decade of UDL. *Learning Disability Quarterly, 33*(1), 33-41. doi:10.1177/073194871003300103

Fong, J. (2012). The Meaning of Pupil Dilation. Retrieved from https://www.the-scientist.com/daily-news/the-meaning-of-pupil-dilation-40076

Goforth-Melroy, J. L. (2014). *Universal Design for Learning: A Program Evaluation of Faculty Implementation.* (Ed.D.). San Diego State University, Ann Arbor. Retrieved from https://search.proquest.com/docview/1562948320?accountid=12964 http://libraries.ou.edu/eresources/resolver.aspx?rft.genre=dissertations+%26+theses&rft.atitle=&rft.au=Goforth-Melroy%2C+Janice+L.&rft.volume=&rft.issue=&rft.spage=&rft.date=2014&rft.btitle=&rft.jtitle=&rft.issn=&rft.isbn=978-1-321-07593-9&sid=ProQuest+Dissertations+%26+Theses+Global ProQuest Dissertations & Theses Global database. (3630003)

Gravel, J. (2017). *A disciplined application of Universal Design for Learning (UDL): Supporting teachers to apply UDL in ways that promote disciplinary thinking in English Language Arts (ELA) among diverse learners*: dash.harvard.edu.

Hall, T. E., Meyer, A., & Rose, D. H. (2012). *Universal design for learning in the classroom : practical applications / edited by Tracey E. Hall, Anne Meyer, David H. Rose*. New York: New York : Guilford Press.

Hasanzadeh, S., Esmaeili, B., & Dodd, M. D. (2018). Examining the Relationship between Construction Workers' Visual Attention and Situation Awareness under Fall and Tripping Hazard Conditions: Using Mobile Eye Tracking. *Journal of Construction Engineering and Management, 144*(7), 04018060. doi:10.1061/(ASCE)CO.1943-7862.0001516

Hidi, S. (1990). Interest and Its Contribution as a Mental Resource for Learning. *Review of Educational Research, 60*(4), 549-571. doi:10.3102/00346543060004549

Hidi, S., & Renninger, K. (2006). The four-phase model of interest development. *Educational psychologist*. Retrieved from https://www.tandfonline.com/doi/abs/10.1207/s15326985ep4102_4

Hollingshead, A. (2018). Designing Engaging Online Environments: Universal Design for Learning Principles. *Cultivating diverse online classrooms through …*. Retrieved from https://www.igi-global.com/chapter/designing-engaging-online-environments/191917

Huey, E. B. (1908). *The psychology and pedagogy of reading*: New York: The Macmillan Company.

IEA. (n.d.). IEA: Internationa Ergonomics Asociation- What is Ergonomics? Retrieved from https://www.iea.cc/whats/index.html

Jeon, J. (2018). *Analysis of Eye Tracking Data to Measure Situational Awareness in Offshore Drilling Operations.* The University of Oklahoma,

Kahneman, D. (1973). *Attention and effort*: Citeseer.

Kang, Z., Dragoo, M., Yeagle, L., & ... (2018). Adaptive learning pedagogy of universal design for learning (UDL) for multimodal training. *Journal of Aviation …*. Retrieved from https://commons.erau.edu/jaaer/vol27/iss1/2/

Kang, Z., & Landry, S. J. (2010). Capturing and Analyzing Visual Groupings of Multiple Moving Targets in an Aircraft Conflict Detection Task Using Eye Movements. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 54*(23), 1906-1910. doi:10.1177/154193121005402301

Kok, E. M., & Jarodzka, H. (2017). Before your very eyes: the value and limitations of eye tracking in medical education. *Medical Education, 51*(1), 114-122. doi:10.1111/medu.13066

Krapp, A., Hidi, S., & Renninger, K. (1992). *Interest, Learning and Development. The role of interest in learning and development*: Hillsdale: NJ: Erlbaum.

Lohmann, M., Boothe, K., Hathcote, A., & Turpin, A. (2018). Engaging Graduate Students in the Online Learning Environment: A Universal Design for Learning (UDL) Approach to Teacher Preparation. *Networks: An Online …*. Retrieved from https://eric.ed.gov/?id=EJ1187583

Marino, M. T., Gotch, C. M., Israel, M., Vasquez, E., Basham, J. D., & Becht, K. (2014). UDL in the Middle School Science Classroom: Can Video Games and Alternative Text Heighten Engagement and Learning for Students With Learning Disabilities? *Learning Disability Quarterly, 37*(2), 87-99. doi:10.1177/0731948713503963

Marshall, S. (2000). Method and apparatus for eye tracking and monitoring pupil dilation to evaluate cognitive activity. *US Patent 6,090,051*. Retrieved from https://patents.google.com/patent/US6090051A/en

Mayu, I., Guangyi, A., & Hiroaki, W. (2015). Simultaneous Recording of EEGs and Eye-Tracking for Investigating Situation Awareness and Working Memory Load in Distracted Driving: A Prospective Analysis Toward the Neuro-Driving Framework. *Frontiers in Neuroscience, 9*. doi:10.3389/conf.fnins.2015.91.00010

Merriam-Webster. (Ed.) Merriam-Webster.

Messinger-Willman, J., & Marino, M. T. (2010). Universal Design for Learning and Assistive Technology: Leadership Considerations for Promoting Inclusive Education in Today's Secondary Schools. *NASSP Bulletin, 94*(1), 5-16. doi:10.1177/0192636510371977

Meyer, A., Rose, D., & Gordon, D. (2014). *Universal design for learning: Theory and practice*: CAST Professional Publishing.

Muehlethaler, C. M., & Knecht, C. P. (2016). Situation Awareness Training for General Aviation Pilots using Eye Tracking. *IFAC PapersOnLine, 49*(19), 66-71. doi:10.1016/j.ifacol.2016.10.463

Mundorf, J. (2014). Teaching reading to a student with blindness using universal design for learning: A practitioner inquiry. In B. Kennedy-Lewis (Ed.): ProQuest Dissertations Publishing.

Murawski, W., & Scott, K. (2019). *What Really Works with Universal Design for Learning*: books.google.com.

Murray, C., Lombardi, A., Wren, C. T., & Keys, C. (2009). Associations between Prior Disability-Focused Training and Disability-Related Attitudes and Perceptions among University Faculty. *Learning Disability Quarterly, 32*(2), 87-100. doi:10.2307/27740359

Novak, K., & Rose, D. (2016). *UDL Now!: A Teacher's Guide to Applying Universal Design for Learning in Today's Classrooms*: CAST Professional Publishing.

Null, R. (2013). *Universal design: Principles and models*: books.google.com.

Parikh, S. (2017). Predicting Levels of Learning with Eye Tracking. In H. Kalva, E. Barenholtz, B. Furht, & D. Raviv (Eds.): ProQuest Dissertations Publishing.

Parker, H. B. (2013). *Learning starts with design: Higher education faculty explore the use of universal design for learning (UDL) to address the needs of all students*: scholarworks.uvm.edu.

Poole, A., & Ball, L. (2006). *... of Human Computer Interaction, chapter Eye Tracking in Human-Computer Interaction and Usability Research: Current Status and Future Prospects*.

Rappolt-Schlichtmann, G., Daley, S. G., Lim, S., Lapinski, S., Robinson, K. H., & Johnson, M. (2013). Universal Design for Learning and Elementary School Science: Exploring the Efficacy, Use, and Perceptions of a Web-Based Science Notebook. *Journal of Educational Psychology, 105*(4), 1210-1225. doi:10.1037/a0033217

Rayner, K. (2009). The 35th Sir Frederick Bartlett Lecture: Eye movements and attention in reading, scene perception, and visual search. *Quarterly Journal of Experimental Psychology, 62*(8), 1457-1506. doi:10.1080/17470210902816461

Roberts, J. A., Yaya, L. H. P., & Manolis, C. (2014). The invisible addiction: Cell-phone activities and addiction among male and female college students.(FULL-LENGTH REPORT)(Report). *Journal of Behavioral Addictions, 3*(4), 254. doi:10.1556/JBA.3.2014.015

Rogers-Shaw, C., Carr-Chellman, D. J., & Choi, J. (2018). Universal Design for Learning: Guidelines for Accessible Online Instruction. *Adult Learning, 29*(1), 20-31. doi:10.1177/1045159517735530

Rosa, P. (2015). What do your eyes say? Bridging eye movements to consumer behavior/?Que dicen sus ojos? Conectando los movimientos oculares hacia el comportamiento del consumidor. *International Journal of Psychological Research, 8*(2), 90. doi:10.21500/20112084.1513

Rose, D. H. (2002). *Teaching every student in the Digital Age : universal design for learning / David H. Rose and Anne Meyer with Nicole Strangman and Gabrielle Rappolt*. Alexandria, Va.: Alexandria, Va. : Association for Supervision and Curriculum Development.

Rotgans, J. I., & Schmidt, H. G. (2011). Situational interest and academic achievement in the active-learning classroom. *Learning and Instruction, 21*(1), 58-67. doi:10.1016/j.learninstruc.2009.11.001

Rotgans, J. I., & Schmidt, H. G. (2014). Situational interest and learning: Thirst for knowledge. *Learning and Instruction, 32*, 37-50. doi:10.1016/j.learninstruc.2014.01.002

Spooner, F., Baker, J. N., Harris, A. A., Ahlgrim-Delzell, L., & Browder, D. M. (2007). Effects of Training in Universal Design for Learning on Lesson Plan Development. *Remedial and Special Education, 28*(2), 108-116. doi:10.1177/07419325070280020101

Tobin, T. (2018). *Re-Framing UDL for Broader Adoption in Higher Education"*: uduc.org.

Vie, S. (2018). Effective Social Media Use in Online Writing Classes through Universal Design for Learning (UDL) Principles. *Computers and Composition, 49*, 61-70. doi:10.1016/j.compcom.2018.05.005

Visual Dictionary Online. Retrieved from https://www.visualdictionaryonline.com/index.php

Webb, K. K., & Hoover, J. (2015). Universal Design for Learning (UDL) in the Academic Library: A Methodology for Mapping Multiple Means of Representation in Library Tutorials. *College & Research Libraries, 76*(4), 537-553. doi:10.5860/crl.76.4.537

Williams, B., Quested, A., & Cooper, S. (2013). Can eye-tracking technology improve situational awareness in paramedic clinical education?(ORIGINAL RESEARCH)(Report). *Open Access Emergency Medicine, 5*, 23. doi:10.2147/OAEM.S53021

Ziho, K., & Landry, S. J. (2015). An Eye Movement Analysis Algorithm for a Multielement Target Tracking Task: Maximum Transition-Based Agglomerative Hierarchical Clustering. In (Vol. 45, pp. 13-24).

Appendices

Appendix A: Example Page of Quiz Given to Participants

Gallogly College of Engineering
School of Industrial and Systems Engineering
The University of Oklahoma

To be filled be the investigator	
Participant ID	Group (Circle One)
	O U

Topic 1: Standard Communication

Q1 (Alphabet Pronunciation)

Based on the material you studied, write the corresponding standard word for each of the following letters:

Letter	Standard Word
B	
C	
G	
I	
L	
M	
O	
P	
Q	
R	
T	
V	
W	

Q2 (Word Meanings)

Provide an example for each word/phrase when you are driving a car.

Word/Phrase	Example
Shall / Must	
Shall Not / Must Not	
Should	
May / Need Not	
Will	

Appendix B: UDL Features Applied to Modified Slides

Example Slide Changes/UDL Features

Topic 1.1 Alphabet Pronunciation

Original

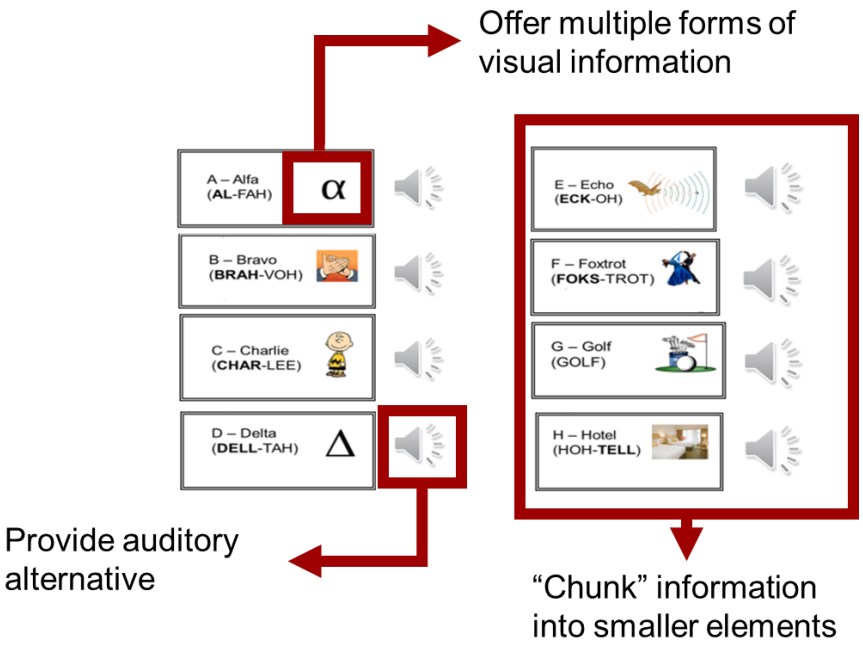
- When it is necessary to state individual letters in radiotelephony, use the ICAO pronunciation of the alphabet listed below to prevent confusion:

Character	Word	Pronunciation	Character	Word	Pronunciation
A	Alfa	**AL**-FAH	N	November	NO-**VEM**-BER
B	Bravo	**BRAH**-VOH	O	Oscar	**OSS**-CAH
C	Charlie	**CHAR**-LEE	P	Papa	**PAH**-PAH
D	Delta	**DELL**-TAH	Q	Quebec	KEH-**BECK**
E	Echo	**ECK**-OH	R	Romeo	**ROW**-ME-OH
F	Foxtrot	**FOKS**-TROT	S	Sierra	SEE-**AIR**-AH
G	Golf	GOLF	T	Tango	**TANG**-GO
H	Hotel	HOH-**TELL**	U	Uniform	**YOU**-NEE-FORM
I	India	**IN**-DEE-AH	V	Victor	**VIK**-TAH
J	Juliett	**JEW**-LEE ETT	W	Whiskey	**WISS**-KEY
K	Kilo	**KEY**-LOH	X	X-ray	**ECK**-SRAY
L	Lima	**LEE**-MAH	Y	Yankee	**YAN**-GKEY
M	Mike	MIKE	Z	Zulu	**ZOO**-LOO

NOTE: For clarity of communications, the syllables in bold print are to be emphasized when pronounced.

Topic 1.1 Alphabet Pronunciation

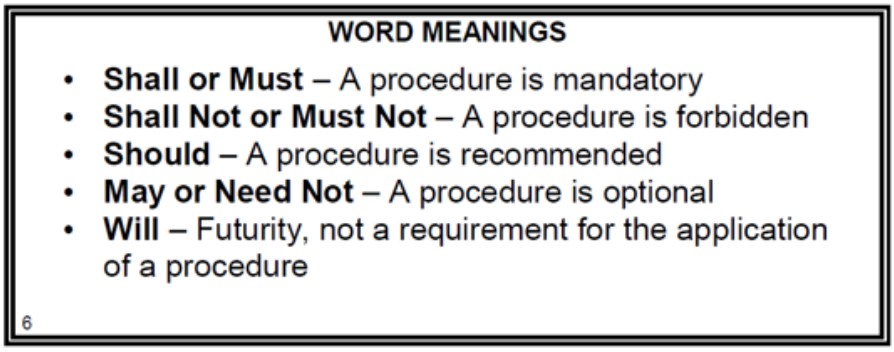
UDL Features



Example Slide Changes/UDL Features

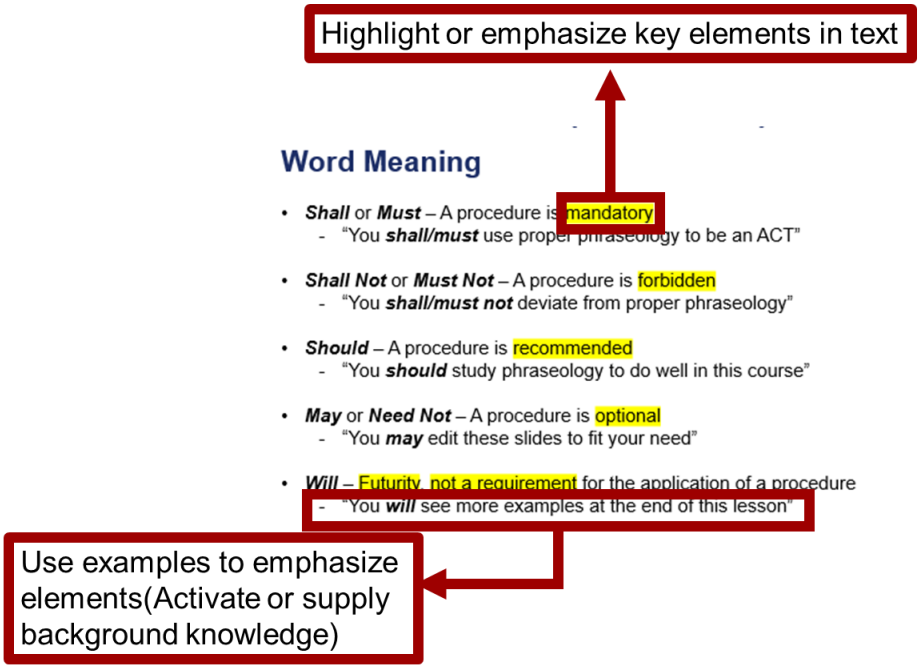
Topic 1.2 Word Meaning

Original



Topic 1.2 Word Meaning

UDL Features



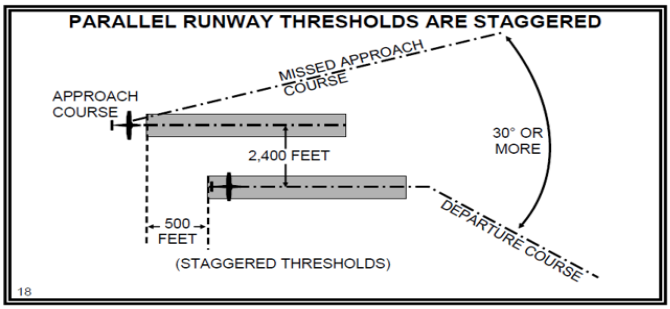
Example Slide Changes/UDL Features

Topic 2.1 Figure Comprehension

Original

RADAR DEPARTURES AND ARRIVALS *(Continued)*

Parallel Runways (Cont'd)
JO7110.65, par. 5-8-5



– Parallel runway thresholds are staggered, and the arriving aircraft is approaching the **nearer** runway.

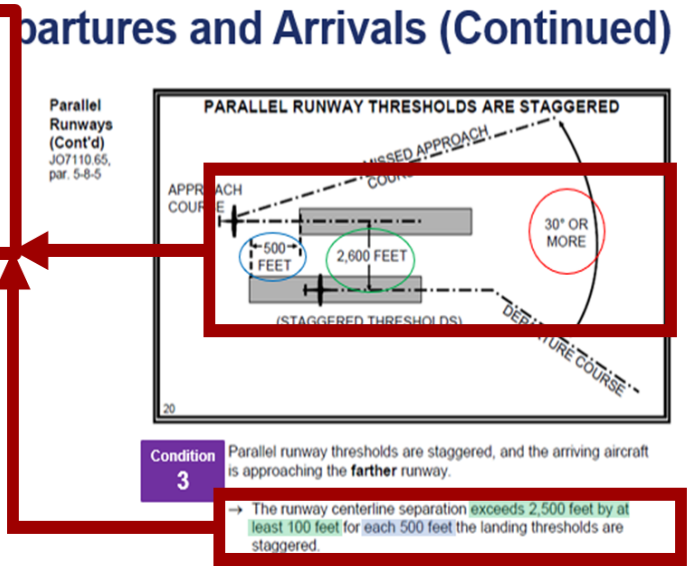
→ The centerlines are at least 1,000 feet apart.

→ The landing thresholds are staggered at least 500 feet for each 100 feet less than 2,500 feet that the centerlines are separated.

Topic 2.1 Figure Comprehension

UDL Features

Make relationships between elements explicit (highlight or emphasize key elements in text)



Example Slide Changes/UDL Features

Topic 2.2 Trend Understanding

Original

RADAR DEPARTURES AND ARRIVALS *(Continued)*

FOR APPROACH TO THE NEARER OF STAGGERED PARALLEL RUNWAYS	
DISTANCE BETWEEN CENTERLINES	**THRESHOLD STAGGER**
2,400 feet	500 feet
2,300 feet	1,000 feet
2,200 feet	1,500 feet
2,100 feet	2,000 feet
2,000 feet	2,500 feet
1,900 feet	3,000 feet
1,800 feet	3,500 feet
1,700 feet	4,000 feet
19	

NOTE: The above table is not all-inclusive. It is meant to give you an idea of how the stagger increases as the distance between the centerlines decreases.

Topic 2.2 Trend Understanding

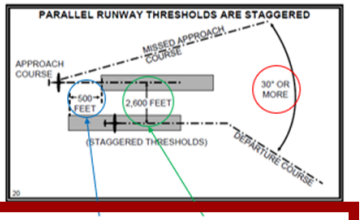
UDL Features

- Guide information processing and visualization
- Make relationships between elements explicit

Radar Departures and Arrivals (Continued)

For Approach to the **Farther** of Staggered Parallel Runways	
Distance Between Centerlines	Threshold Stagger
2,700 feet	1,000 feet
2,800 feet	1,500 feet
2,900 feet	2,000 feet
3,000 feet	2,500 feet
3,100 feet	3,000 feet
3,200 feet	3,500 feet
3,300 feet	4,000 fee

NOTE:
Recognize the **positive linear relationship** in comparison to the nearer staggered parallel runways shown previously.



Threshold stagger — Distance between centerlines

When increases↑, increases↑

When decreases↓, decreases↓

Example Slide Changes/UDL Features

Additional slide highlighting inverse relationship between the types of runways

Illustrate through multiple media (e.g. providing additional visual guidance, table, diagrams, charts, etc.),