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Graphics Visualizations and their Relation to Expertise Level and the Expertise Reversal Effect on Engineering Students

by

Amani Binmahfooz

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy in the Department of Instructional Design

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To the Graduate Faculty:

The members of the committee appointed to examine the dissertation of Amani Binmahfooz find it satisfactory and recommend that it be accepted.

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RE: regarding study number IRB-FY2018-95: Graphics Visualizations and their Relation to Expertise Level and the Expertise Reversal Effect on Engineering Students

Dear Ms. Binmahfooz:

I agree that this study qualifies as exempt from review under the following guideline: Category 1. Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
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Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

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Graphics Visualizations and their Relation to Expertise Level and the Expertise Reversal Effect on Engineering Students

Dissertation Abstract- Idaho State University (2019)

Graphics in the form of video have been shown to be useful in presenting information to students. When designing graphic videos to optimize student learning, designers must take into consideration which elements will enhance student learning and which ones will hinder the process. In this study, the researcher presented two groups of engineering students, novices and experts, with two types of graphic videos: one simultaneous and one sequential. After viewing each video, students answered a survey and were tested on the videos' content. The survey answers were used to measure the effect of each video on student motivation. The test scores were used to measure the effect of each video on student achievement.

This research sought to answer whether there is a main effect of the graphic types or learner expertise level on the students' achievement and motivation as well as whether there was an interaction effect between the graphic types and learner expertise level on the learner achievement and motivation. The results of this study found that there was a statistically significant effect of graphic types on learner achievement and motivation. This study also found that there was a statistically significant effect of learner expertise levels on learner achievement and motivation. The achievement tests scores and CIS surveys scores on sequential graphic on vector addition and simultaneous graphic on friction showed that there was no statistically significant interaction (expertise reversal effect) between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner achievement and motivation.

Key Words: Cognitive Load, Expertise Reversal Effect, Graphics, Multimedia, Sequential Dynamic Graphics, Simultaneous Dynamic Graphics

CHAPTER I

Introduction

E-learning is a general type of education that utilizes different tools such as text, graphics, animation, sound, and video to present information to learners through digital formats (Anaraki, 2004). Multimedia makes the use of all these tools to present static or animated graphics as well as written or spoken words (Clark & Mayer, 2011). Therefore, multimedia is frequently used as a means to relay information to learners in an E-learning environment.

When designing multimedia to use in E-Learning, instructional designers should strive to structure educational information in a meaningful way and consider the previous learning experiences for students (Mayer & Sims, 1994). Instructional designers follow models to help students to retain the information and increase their experiences. Studies have shown students reached a higher rate of learning when class content is presented in a multimedia format (Mayer & Sims). As Clark and Mayer stated, “There is consistent evidence that people learn more deeply from words and pictures than from words alone, at least for some sequential instructional situations” (2011, p. 79). These authors referred to two types of pictures: static images such as charts and graphs, and dynamic images like animations and videos (Clark & Mayer, 2011). Each type of graphic visualization (static and dynamic) may be presented in two modes, sequential or simultaneous. The sequential mode shows graphics one at a time in order. In contrast, the simultaneous mode presents all the graphics on the same page or screen (Imhof, Scheiter, & Gerjets, 2009).

Kalyuga, Chandler, and Sweller (2001) stated that instructional designers must consider their audience when designing learning experiences, and must take into consideration whether the information will be viewed by experienced or novice learners. Prior studies have shown that students with a higher experience level generally interpret information better than novice learners (Kalyuga, Chandler, & Sweller, 2001). These researchers also said that instructional designers benefit from understanding the technological advancements that provide a wider range of graphics and presentation methods, and from using informational delivery methods such as computer presentations tools (2001).

McLaughlin (1994) stated that human learners in general, regardless of experience level, have limited abilities to process information. This author also asserted that tasks can use a large processing capacity or can be performed automatically, requiring little processing energy. The information processing system consists of sensory memory, working memory, and long-term memory (Mayer, 2002; Van Essen, Anderson, & Felleman, 1992). When the learners are presented with information in the form of multimedia, the words and the pictures access the processing system through the eyes and ears as sensory memory; then the brain temporarily stores the information in a working memory (Mayer, 2002; Van Essen, Anderson, & Felleman, 1992).

Cognitive load theory (CLT) is based on the limited capabilities of working memory as one part of the human information processing system (Ayres & Van Gog, 2009). Leppink et al. (2014) identified three types of Cognitive Load: intrinsic, extraneous, and germane cognitive load. Intrinsic and germane cognitive loads are similar to each other in that they both deal with relating information to existing schema.

Extraneous cognitive load can interfere with learning because it is created by excess information that has no relevance to the information being learned, therefore, the brain filters the information out (Wong, Leahy, Marcus, & Sweller, 2016). Van Merrienboer and Sweller asserted that CLT presumes that human working memory is limited, able to hold about seven elements (2005). However, human working memory can operate on between two to four elements (Van Merrienboer & Sweller, 2005). With that assumption in mind, those authors pointed out that it was important to reduce extraneous cognitive load. CLT in multimedia can be applied to maximize available cognitive resources for learning by taking this into consideration (Van Merrienboer & Sweller, 2005).

Five cognitive processes: choosing relevant words, focusing on pictures or images, organizing selected words, categorizing selected images, and combining selected pictures and words together -- all work to determine which information is transferred to long-term memory (Mayer, 2002). Mayer and Moreno (2003) stated that the cognitive theory of multimedia learning addresses how learners process information from a multimedia presentation containing words and pictures. The information from the presentation enters the learners' sensory memory through their eyes and their ears. Learners translate the sounds and images into verbal and pictorial models in working memory. Then the brain stores the information in the long-term memory as knowledge (Mayer & Moreno, 2003).

The load level the brain experiences when dealing with choices is called the perceptual load. Roper, Cosman, and Vecera (2013) found that it can be difficult for the human brain to process excessive amounts of visual information. The authors stated that the brain must select some pieces of information over others to correctly interact with the environment. Additionally, Roper et al. found perceptual load to be important to general focus of attention. It is determined by whether the brain remains highly focused or attention is divided among pertinent items (Roper, Cosman, & Vecera 2013).

Khacharem, Zoudji, Kalyuga and Ripoll (2013) studied the effectiveness of multimedia instruction and found that it could sometimes be limiting depending on the type of graphics used and the learners' experience. Khacharem et al. stated that dynamic visualizations such as animations may be too complicated for students to understand and manage because of the limitations on working memory (2013). Ayres and Van Gog (2009) stated that animations can add to extraneous cognitive load because elements shift and move at the same time which can overextend learners' working memory. Additionally, animations can add to the intrinsic cognitive load because they often contain numerous elements interacting together, which makes them harder to learn than the ones containing fewer interacting elements (Ayres & Van Gog, 2009).

Khacharem et al. (2013) found that when learners were presented with simultaneous and sequential graphics, the result was the expertise reversal effect made learning from the sequential graphics more difficult for experienced learners. The expertise reversal effect (ERE) occurs when the graphic include information that benefits novices but is not helpful for the expert learner (Kalyuga et al., 2003). In other words, excess information that the expert learners don't need can causes ERE.

Research Problem

Kalyuga and Renkl stated that while the body of research continues to develop and grow around the topics of different levels of prior knowledge, there are some areas related to the learner experience levels in need of further research (2010). These researchers stated that learners of different expertise levels benefit from multimedia; however, they cited the need for more research to identify elements of instructional design that can assist in creating multimedia lessons that improve learning across all experience levels. Kalyuga and Renkl's (2010) study showed that multimedia in learning could be optimized for a broader range of instructional designs and procedures, so the multimedia for a given subject can be understood by learners with different levels of expertise. However, Clark and Mayer reported, “the expertise reversal effect is the idea that instructional supports that help low-knowledge learners may not help (and may even hurt) high-knowledge learners” (2011, p. 83).

Imhof, Scheiter, and Gerjets (2009) asserted that there are two types of dynamic graphics, sequential and simultaneous. Moreno and Mayer (1999) explained that sequential dynamic graphics are two or more images that are separated spatially so they cannot be seen at the same time. According to Beichner (1990), simultaneous dynamic graphics are images that are synchronized and presented together so that learners can see them at the same time. Moreno and Mayer found that sequential dynamic graphics were beneficial for teaching novice learners, but sequential dynamic graphics may cause the expertise reversal effect for experienced learners (1999).

This study focused on the use of dynamic graphic types (specifically, dynamic graphics in video form) and their relationship with the experience level of students. It also tested the main effect of both video type and expertise level on both achievement and motivation of students.

Purpose of Study and Research Questions

The purpose of this study was to determine the effectiveness in using both simultaneous and sequential dynamic graphics with learners of differing experience levels so instructional designers can create effective instruction. Additionally, the researcher wanted to see if it would also allow insight into how to achieve better results with both novice and expert students without causing ERE to occur. Mayer (2002) stated that multimedia instructional messages were effective as communication tools for encouraging learning. The combination of words and pictures helps to deliver the information to the learner better than using words alone (Mayer, 2002). As a rule of thumb, the students with a higher experience level interpret information better than novice learners. (Kalyuga, Chandler, & Sweller, 2001)

Multimedia can be designed to optimize learner understanding of the instructional message without overburdening cognitive systems. For example, Spanjers, Wouters, van Gog, and van Merrienboer (2011) stated the segmented animations of longer videos (sequential graphic) assisted the novice learners. However, segmented animations increased the cognitive load for experienced learners and caused the expertise reversal effect for them (Spanjers et al., 2011).

Sequential and simultaneous graphics were tested with novice and experienced learners in this study. This design was studied to see the main effect of each type of graphics on the motivation and achievements of learners with different experience levels, as well as determine the best ways to design multimedia instruction by showing whether sequential or simultaneous graphics are more effective for teaching learners of different experience levels. Some sequential graphics have an interaction effect learners that may cause an expertise reversal effect to occur (Khacharem et al., 2013).

In order to address these purposes, the following research questions were studied:

RQ 1 Do graphic types (sequential and simultaneous) and student expertise levels (novice or expert) have effects on student achievement in an engineering class as measured by class tests?

RQ1.1 Is there a statistically significant main effect of graphics type on student achievement as measured by class tests?

RQ1.2 Is there a main effect of student expertise levels on student achievement in engineering class as measured by class tests?

RQ1.3 Is there an interaction effect between graphic types (sequential and simultaneous) and student expertise (novice or expert) on student achievement in engineering class as measured by class tests.

RQ 2 Do graphic types (sequential and simultaneous) and student expertise levels (novice or expert) have effects on motivation in an engineering class as measured by Keller's *Course Interest Survey*?

RQ2.1 Is there a main effect of graphic types (sequential and simultaneous) on student motivation on engineering class as measured by Keller's *Course Interest Survey*.

RQ2.2 Is there a main effect of student expertise (novice or expert) on student motivation on engineering class as measured by Keller's *Course Interest Survey*.

RQ2.3 Is there an interaction effect between graphic types (sequential and simultaneous) and student expertise levels (novice or expert) on student motivation on engineering class as measured by Keller's *Course Interest Survey*.

Research Design

The quasi-experimental design was used to help answer the research questions. The experiment was conducted with senior engineering students registered for an online class (see Table 1).

Table 1.
Quasi-experimental Group Design for Achievement and Motivation

Pretest	Assignment	Treatment .1 sequential Graphic	Motivation Survey (CIS)	Achievement Test	Treatment .2 Simultaneous Graphic	Motivation Survey (CIS)	Achievement Test
O_1	Expert	X_1	O_2	O_4	X_2	O_6	O_8
O_1	Novice	X_1	O_3	O_5	X_2	O_7	O_9

Note. X = Graphic type treatment O = Observation

The students were given a pretest to determine the learner experience level (see Appendix C), their scores were used to divide them into two groups. One group consisted of novice learners and the other more experienced learners. Each group first viewed the multimedia presentation of course information using sequential dynamic graphics, then tests were given to the students to measure their motivation and achievement. This process was repeated after students viewed a second lesson using simultaneous dynamic graphics.

Definition of Terms

Cognitive load. Cognitive Load is the human cognitive architecture, specifically the limit of working memory. There are three types of Cognitive Load: intrinsic, extraneous, and germane cognitive load (Leppink et al., 2014).

Cognitive Load Theory (CLT). According to Ayres & van Gog, “Cognitive Load Theory (CLT) is based on a model of human cognitive architecture that assumes that working memory (WM) is very limited in terms of being able to store and process information” (2009, p. 253).

Expertise Reversal Effect. ERE appears when an instructional design includes information that helps novices but hinders the expert learner (Kalyuga et al., 2003). Khacharem et al. stated that some uses of dynamic graphics specifically, sequential dynamic graphics, could cause the Expertise Reversal Effect (2013).

Graphics. Wiley described graphics as images used to increase learners' visual perception (1990). For the purpose of this study, graphics referred to images in the form of video.

Keller's Course Interest Survey (CIS). Keller's CIS is a tool designed to measure students' motivation to learn. It was designed using the four elements Keller (1987) identified for measuring motivation, specifically attention, relevance, confidence, and satisfaction.

Multimedia. Clark and Mayer (2011) define multimedia as the presentation of still or animated images along with words, either written or spoken. They stated that well-designed multimedia instruction contains both graphics and words which work together to encourage student understanding (Clark & Mayer, 2011).

Perceptual Load. Roper, Cosman, and Vecera (2013) found excessive amounts of visual information may be difficult for the human brain to process. The perceptual load referrs to the load level the brain experiences when dealing with choices; the brain must select some pieces of information over others to correctly interact with the environment (Roper, et al., 2013).

Sequential Dynamic Graphics. Sequential dynamic graphics present informational material broken down into small and uncomplicated sections that are shown in sequential increments to the students in video form (Khacharem et al., 2013).

Simultaneous Dynamic Graphics. Simultaneous dynamic graphics combine several steps together and present more information at one time compared to sequential dynamic graphics (Khacharem et al., 2013).

Limitations

Limitations are the issues in the study that the researcher does not have control over which weakens the conclusions of a study and challenges internal validity (Creswell, 2013). Identifying limitations in this study allows future researchers to avoid them when conducting similar studies to improve confidence and validity in future research. Eight limitations were identified by Campbell and Stanley (1963) and four more limitations were later added to the list by Cook and Campbell (1979). These limitations include history, maturation, testing, instrumentation, statistical regression, differential selection, experimental mortality, selection-maturation interaction, experimental treatment diffusion, compensatory equalization of treatment, compensatory rivalry by the control group and resentful demoralization of the control group. In this research, the limitations could be:

Statistical Regression. With repeated measurements, the scores of extreme cases tend to become less extreme. This is known as statistical regression (Campbell & Stanley, 1963). The researcher will check for outliers in all test distribution to identify possible examples of regression to the main. Extreme outliers may be removed from the data set.

Differential Selection. Another limitation in this study is the sampling procedure (Creswell, 2002). The subjects will be students who are already enrolled in an engineering class, and the researcher will work with the entire class without any control over choosing the participants in the study. As in many qualitative studies, the findings of this research could be subject to alternative interpretations (Creswell, 2002).

Selection-Maturation Interaction. Random selection was not used to choose students for this experiment. Additionally, the information presented in the dynamic video graphics will relate directly to the participants' educational background. However, the short duration of the study means there is a potential of selection-maturation interaction in this study.

Delimitations

Delimitations are elements in a study which the researcher does control r and are used to reduce and focus the scope of the study (Creswell, 2002). While limitations result from implicit factors of the experiment design, delimitations appear as result of the choices of the researchers (Simon & Goes, 2013). Bracht and Glass (1968) identified twelve factors that may affect external validity and reduce confidence in the findings of a study. These delimitations are: experimentally accessible population vs. target population, interaction of personological variable and treatment effects, describing the independent variable explicitly, multi-treatment interference, Hawthorne effect, novelty and disruption effects, experimenter effect, pretest sensitization, posttest sensitization, interaction of history and treatment effect, measurement of the dependent variable, and interaction of time of measurement and treatment effects.

Experimentally Accessible Population vs. Target Population. The target population for this study is college students enrolled at a medium-sized university in the Intermountain West in the College of Engineering. Those students also make up the accessible population, as the students available as subjects for this study are enrolled in engineering classes.

It may be difficult to generalize the findings of this study to a broader population than engineering students at this university. The students were not randomly assigned but were already enrolled in a specific program. Also, the students are upper and under class engineering students, so the experiment will not be performed with students of other subjects.

Additionally, students from other universities with different backgrounds and from different demographics may respond differently or have react differently to learning from information presented as dynamic video graphics. These issues may interfere with efforts to generalize this study’s findings to students from other universities.

Interaction of Personological Variables and Treatment Effects. The characteristics of the subjects are what define personological variables that can limit the generalization of the results of this study to larger populations. There is a possibility of this delimitation occurring, as the researcher will not meet the subjects in person and will not be able to determine whether there are significant differences in their prior knowledge that could have an effect on how the dynamic videos affect their achievement and motivation.

Interaction of History and Treatment Effect. There are several possible historical events that Bracht and Glass (1968) identified as having the potential for interacting with the treatment effect. Those events are emotionally-charged events, local or national political events, or unusual student morale conditions. It is unknown whether any of these events will occur during this study.

Measurement of the Dependent Variable. The dependent variables of student achievement and motivation will be significantly tied to the subject matter being presented. This could limit generalization of the findings to other topics in the major field of engineering or other majors and areas of study.

Significance of the Study

Incorporating multimedia in the learning process allows the students to absorb the information more consistently and deeply (Leow & Neo, 2014). Though research has been conducted on learner experience levels, Kalyuga and Renkl (2010) stated that it is a topic that requires further study. It has been shown that multimedia, in general, benefits learners of different experience levels, but the studies were focused on a broad range of instructional procedures and designs so that multimedia instruction can be understood by learners with both expert and novice experience (Kalyuga & Renkl, 2010). The level of learner's experience may determine the effectiveness of instructional simultaneous graphics and sequential. Therefore, the learner's experience is a critical factor in designing instructional graphics (Kalyuga, Chandler, & Sweller, 2001). This study will have a less broad focus to fill the research gap and will show the effects of the different type of graphics with different learners experience levels on their achievement and motivation.

CHAPTER II

Review of Literature

The purpose of this research is to study the effect of simultaneous and sequential multimedia graphics in class and how the engineering students respond to multimedia graphics as a means of delivering educational information. The study will be done in an E-Learning setting with instructional multimedia presentations, which have been built using the multimedia principle, and using two types of video graphics, simultaneous and sequential videos. Additionally, this study will use the ADDIE model which is an instructional design model. As a result, the researcher will take into account studies on eye tracking, cognitive load, perceptual load, and the experience in learning. This research review will examine whether video graphics interact with the learners' experience level to cause an expertise reversal effect. Finally, the study will examine how simultaneous and sequential multimedia graphics affect motivation and achievement of students of different experience levels.

E-Learning

Anaraki (2004) stated that the E-Learning's effectiveness in a learning environment is based on the use of multimedia in variety of ways to present information. The technologies that utilize multimedia for E-Learning incorporate different types of instruments together such as graphics, animation, video, text, and sound (Anaraki, 2004). This author defined two types of multimedia for learning; one is a more passive medium (videotape), and the other is a less passive medium (interactive software). In Anaraki's (2004) paper, the author outlined a study in which subjects were trained, some by viewing a videotape and some learning from interactive software. The study showed that the interactive software increased learner engagement in E-Learning systems better than viewing videotapes.

Moore et al. (2010) pointed out the similarities between E-Learning and online learning while asserting that they are two different types of learning. These authors stated that with online learning, students must access the electronic resources for E-Learning using technology such as the Internet.

Instructional design. Instructional design is the systematic process of designing educational presentations based on proven systems (Morrison, Ross, Kalman, & Kemp, 2011). The purpose of instructional design is to increase the effectiveness and efficiency of learning (Morrison et.al. 2011). These authors state a successful instructional design will improve the learning experience and outcome for students. Instructional design has several models, such as ADDIE, Dick and Carey, R2D2, ICARE, Kemp, Hannafin and Peck, Rapid Prototyping, Gagne's 9 events of instruction, etc. The instructional designer must take into consideration the same basic factors: learner experience, the objective of the class, the accessible materials and technologies, and the applicable tools for measuring the achievement.

Gustafson and Branch (2002) also stated that all types of instructional design should include the same basic characteristics. The characteristics these authors identified are that the instruction be learner-centered, goal oriented, empirical, focus on real-world application, and the outcomes should be able to be measured in a sound and reliable way.

ADDIE ID model. According to Molenda (2003), one of the most recognized and widely used ID models is the ADDIE model. This model was popularized in the 1970s by Florida State University’s Center for Educational Technology for the U.S. Army (Molenda, 2003). Comprised of five phases—Analyze, Design, Develop, Implement, and evaluate -- the ADDIE model offers valuable guidance for instructional designers. It should be noted that the five phases of the model are sequential with the success of each phase relying on the effective completion of the phases that come before it (Welty, 2007).

The Analysis phase of the model begins with clarifying the instructional problem. Forest (2014) described this phase as when the learner's experience level and skills are determined and those, coupled with the learning environment, allow for goals to be set. In this phase, instructors are concerned with identifying their audience and characteristics, establishing a new behavioral outcome, distinguishing types of learning limitations, choosing delivery options along with online pedagogical considerations, and setting a timeline for completing the project (Forest, 2014). There are 14 tasks in this phase Strickland, Strickland, Wang, Zimmerly & Moulton, 2013). The tasks are: rationale, goal, objectives, concept map, learning influence document, expected learning outcome document, learning hierarchy document, learner characteristics document, target audience document, learner constraints document, pedagogical considerations document, learner constraints document, delivery options document and analysis timeline document (see Appendix G)

The Design phase is organized and precise. During this phase, essential elements are identified such as learning objectives, content, exercises, instruments for assessment, analysis for the subject matter along with lesson planning, and selecting the graphics and media (Forest, 2014). Additionally, this author outlined the steps for the design phase as being: gathering instructional documentation for the project, determining an approach for visual and technical design, applying instructional strategies based on the desired behavioral outcomes by domain (cognitive, affective, psychomotor), creating task analysis (see Appendix N), flowchart (see Appendix O), storyboards (see Appendix P), designing a user interface, creating a useable prototype and finally completing a visual design application. (Forest, 2014).

Once the design was approved, the Development phase followed. According to Welty, this phase is when the performance gap is addressed and the educational products are developed (2007). Morrison, et.al. (2011) outlined the important elements of effective development include controlling the step size and pacing, so the learners won't be overwhelmed with a lot of presented information at once.

The Implementation phase is next. This is the point at which the training and assessment materials are tested to determine their effectiveness in a real-world setting (Welty, 2007). Davis (2013) said that, "The *implementation* phase includes the testing of prototypes where training for the instructor happens followed by learners participating in the instruction."

Finally, during the Evaluation phase, the instructor gauges how successful the curriculum was, and whether it needs to be improved for the next implementation phase. According to Wang and Hus (2009), this phase consists of formative and summative evaluations. The evaluator conducts a formative evaluation in each phase to determine the level of effectiveness and quality of the individual phases. The evaluator also conducts summative evaluations with tests designed for domain-specific, criterion-related items and collects feedback from users (Wang & Hus, 2009).

By adopting ADDIE, implementing the learning activity improves chances of effectively advancing learners' knowledge and skills (Wang & Hus, 2009). Wang and Hus stated that it is the best option for ensuring that learners gain knowledge and skills that can be effectively applied in their professional fields (2009). Rodriguez (2012) stated that the ADDIE model's cost effectiveness is one of its valuable strengths, along with the advantage of saving time for both the learner and the instructor. The model's consistency makes it effective for training which, in turn, makes it effective for learning. Additionally, Welty stated, as an iterative feedback model, the ADDIE model offers extra refinement of the learning product because the results of the Evaluation phase are returned to the origination point as feedback, effectively closing the loop (2007).

Multimedia

Mayer (2002) defined multimedia as the presentation of words, written or spoken, together with pictures. This author explained that students learn better with multimedia. A well-designed multimedia instructional message is made up of graphics and words which is designed to facilitate learning (Mayer, 2002). Mayer examined the effects of multimedia, specifically instruction presented in pictures and words instead of using just words alone. His research showed how students learn from words and pictures and resulted in the Multimedia Principals of learning, including the coherence principle and the segmenting principle (2002). Morrison et al. (2011) stated that multimedia can be live action video or animated graphics. Neither has been proven to be more effective than the other, but that animated multimedia can be more efficient and cost-effective to produce than live-action video (Morrison et.al, 2011).

Multimedia Principle. The multimedia principle recommends presenting materials to students using two formats such as words and graphics (Mayer & Sims, 1994). Clark and Mayer (2011) conducted two separate studies comparing the effectiveness of teaching using the multimedia principle, i.e. animation and narration with text, or text alone. The results of those studies showed that the students who were taught using the multimedia principle more effectively retained information and performed better on class tests than their counterparts who were taught using only text or narration (Clark & Mayer, 2011).

Coherence Principle. According to Mayer (2002), learning is easier for students learn when extraneous material is not included. The coherence principle can be explained in three different but related ways: (a) student learning is hindered when interesting but unrelated words and pictures are included in multimedia instruction; (b) student learning is hindered when interesting but unrelated sounds including music are included in multimedia instruction; and (c) student learning is increased when unneeded words are left out of multimedia instruction.

Segmenting principle. According to Mayer (2005), students learn better when multimedia instruction is presented in short sequences rather than in a continuous presentation. The segmenting principle is broken down into three separate rationales: (a) theoretical rationale, when watching fast-paced narrated multimedia instruction, some students may not have enough time to fully understand one step in the presentation before the next step is presented, therefore, students may not fully comprehend the causal relationship between steps; (b) empirical rationale, students performed better on three out of three problem-solving transfer tests when multimedia instruction was presented in small segments that were initiated by the students, rather than when the information was presented in a continuous unit. The effect size was .98; (c) boundary conditions, the segmenting principle mostly applies when the instructional content is complex, the multimedia presentation is fast-paced, and the material is completely new to the student (Mayer, 2005).

Building the Multimedia. Moreno and Mayer (1999) asserted that the cognitive theory of multimedia learning included five steps in developing multimedia learning. The first step is taking significant words from existing narration or text. The second step is choosing appropriate images from illustrations in a presentation. The third is arranging the chosen words into a clear and logical order. The fourth step is placing the images into a sequence that corresponds to the verbal presentation. The last step is combining the images and words to include information that benefits novices. The study concluded that using those processes maximized the effect of multimedia instructional messages (Moreno & Mayer, 1999). In this study the researcher will apply these steps to build the multimedia videos for this experiment.

Achievement. Mayer & Sims have shown that students have better learning outcomes from multimedia, which is a valuable tool for driving learners to pave achievement pathways (1994). Multimedia is a useful tool to encourage students to accomplish specific outcomes through channels that have proven effective learning to reach those outcomes (Antonietti & Giorgetti, 2006). Mayer (2003) found that learning outcomes were more efficiently stored in long-term memory to be used later by the learner. Additionally, his research showed information presented in a form of multimedia induced active learning in students to allow them to effectively catalog the learning outcomes in a long-term memory to be used to solve problems in the future (Mayer, 2003).

Research by Bailey, Taasoobshirazi, and Carr (2014) studied how pictorial representations directly impact achievement. The study tested the influence of motivation, achievement emotions, pictorial representation, and categorization skills variables on how students perceived multimedia instructional material. The study also examined how these variables interacted with each other in relation to learning. These authors stated that students who drew more complex pictures were more likely to set up and solve geometry problems correctly. (Bailey et al., 2014)

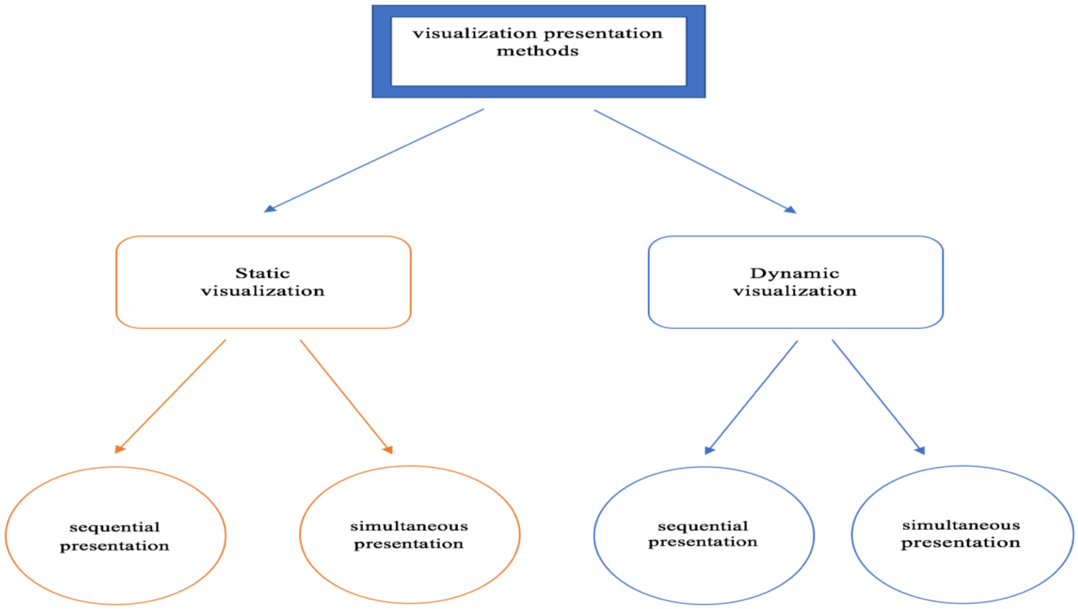
Surjono (2015) found that students who learned from multimedia materials had higher achievement than students who learned from traditional methods in a classroom such as written materials and lectures. This author found that presenting learning materials as graphics increases achievement by encouraging students to think and use cognitive skills more effectively. Surjono also asserted that the motion in animated graphics make abstract concepts easier to understand, which can also increase achievement (2015).

Graphics. Bucher and Niemann defined visualizations as visual means of communicating ideas or information such as images or pictures, written text, or audio-visual data (2012). According to these authors' research, *Visualizing Science: The Reception of PowerPoint presentations* (2012), visualizations are communication and learning dates back to the 19^{th} century. Those researchers classified graphics depending on the absence or presence of motion into static and dynamic categories (2012).

Clark and Mayer (2011) mentioned that there are two types of visualizations, static and dynamic. Static is when information is given in a non-moving format. Examples of static visualizations would be the use of charts or graphs to provide information to learners (Clark & Mayer, 2011). The second type, dynamic visualization, utilizes a type of movement to present a knowledge or course content. Clark and Mayer identified two types of dynamic visualization, animation and video (2011).

Imhof, Scheiter, and Gerjets (2009) identified two basic visualization presentation methods, sequential presentation method and simultaneous presentation mode. Imhof et al. (2009) explained that in sequential presentation mode, the visualizations were presented successively. On the other hand, the simultaneous presentation mode presents more information to the learners at the same time instead of successively (Imhof et al., 2009). These modes can be used for both static and dynamic visualizations (see Figure 1).

Figure 1.
The visualization presentation methods.



According to Burt (1999), videos combine audio and visual information. They can be used in a variety of ways for instruction and education including in-classroom settings and online learning, even for students of different experience (Burt, 1999). The author highlighted the controllable elements of video, the ability to be paused, rewound, stopped as well as easily accessed by individuals and groups, as making videos useful in learning.

Videos can be used to demonstrate real world skills and techniques, summarize lessons, chapters from textbooks, or provide supplemental material to enhance understanding (Kay, 2012). Three experiments studied the creation of multimedia videos for podcasts (Alpay & Gulati, 2010; Armstrong & Massad, 2009; Kay, 2012). Students in those studies reported improvement to analytic, creativity, cooperation, communication, and technology skills. Four additional studies made stronger statements about how video impacts learning. Those researchers noted that students found that their performance improved as a direct result of viewing the multimedia videos (Brittain et al., 2006; Crippen & Earl, 2004; Dupagne et al., 2009; Kay, 2012).

Another study showed that the video was more effective in enhancing learning, such as improving reading comprehension for EFL learners (Niknejad & Rahbar, 2015). When presented with multimedia graphics and text, students' reading comprehension improved more effectively than students who were shown only text with no graphics. Additionally, these authors stated that video allows learners to experience different methods of learning which also increased the students' motivation (Niknejad & Rahbar, 2015).

Burt (1999) pointed out the importance of the type of video used for instruction. Herreid and Schiller (2013) said that the majority of both teachers and students prefer video as a preferred method of instruction, but teachers have difficulty finding videos of good quality. For example, Burt (1999) stated that "authentic video" which is classified as movies, television shows, or news programs, require the viewer to analyze what they hear and see, reducing their effectiveness at explaining simultaneous concepts. Further, when instructors attempt to create videos, the quality can be marginal (Herreid & Schiller, 2013). It meant inferior elements, such as focus and clarity, could contribute to how students receive and interpret the information. Other techniques that facilitate refocusing video and still images are useful tools for editing video to enhance the presentation (Moreno-Nogue et al., 2007).

For the purpose of this study, two levels of graphics will be used, simultaneous and sequential. Sequential graphics are defined as a video presentation with content presented in small bites including written words and spoken narration display; the video includes comprehensive steps of a procedure in sequential order. Simultaneous graphics present the same content as sequential graphics but at the same time, which may deliver excessive information for some students. However, the excess information may not always be helpful for all students (Canham & Hegarty, 2010).

Motivation

Motivation is also a dependent variable of this research. There are different studies relating motivation to many different fields including achievement and multimedia (Meyer, McClure, Walkey, Weir & McKenzie, 2009; Moshirnia, 2007; Keller, 1987; Fui-Theng & Mai, 2014).

Meyer. et al., stated it is essential for students' achievement outcomes and is important for catching and holding learners' attention (2009). Two to four weeks before final exams, these researchers had students complete a survey designed to measure motivation. Comparing the survey answers to students' final grades showed that the higher motivated students tended to be the ones with higher achievement in the class.

Moshirnia found that graphics can play a key part in encouraging motivation in learners (2007). Motivation has been defined as the state in which a person is encouraged to have interest in his surroundings and a desire to achieve his best (Keller, 1987). In a learning environment, this motivation can be defined in terms of attention, relevance, confidence, and satisfaction (Keller, 1987).

A study by Fui-Theng and Mai (2014) found that multimedia was effective for increasing learner motivation. These researchers provided students with an Interactive Learning Model (ILM) presented on computers designed with multimedia as a basis for presenting the information. The results of the study showed the percentage of students that found the method held their attention during the learning process was 74.2%, and found 83.9% of the students increased their motivation to learn by that method (Fui-Theng & Mai, 2014).

Designing multimedia lessons is enhanced by using Keller's ARCS model (Keller, 1993). The author stated that the ARCS model has been used extensively in research and instructional design. Keller and Subhiyah (1993) first outlined four elements essential for encouraging motivation in learners. Keller (2011) found that learners are naturally motivated to learn when: a) the instructor captures and sustains their *attention*; b) they find the instructional information to be *relevant* to them personally; c) they are *confident* the learning experience will result in personal successful performance; d) they can see that the learning experience will have a *satisfying* outcome. Additionally, Keller stated that learners remain intrinsically motivated when they experience the successful learning outcome they anticipated. Obtaining satisfaction from the learning experience creates a desire to persist in learning to achieve a larger goal (Keller, 2011).

Huett (2006) asserted that Keller's ARCS model is the most complete and comprehensive model for instructional design that promotes motivation. In other words, Keller's ARCS model is considered the best model for motivational design (Ocak & Akcayir, 2013) and its effectiveness has been proven in numerous studies. Molaee and Dortaj's research (2015) is just one example. In their study on motivational design, they found the ARCS model to be effective in instructional motivational design, with learners showing "obvious improvement" in scores after learning from the ARCS-influenced information (Molaee & Dortaj, 2015, p. 1219).

Sequential graphics and motivation. Student motivation is affected when information is presented in short, easy to process pieces. Providing instruction as sequential graphics achieves the goal of engaging students' attention and making information easier for them to understand. Additionally, students are able to retain information they can understand. In a study by Oz, et al., researchers found that sequential animations supported student motivation (2013).

Cognitive load

Cognitive Load Theory is an essential part of instructional design; Ozcinar stated that "Cognitive Load Theory was the second most frequently used (n = 131, 12.83%)" element by instructors for instructional design (2009, p. 566). Leppink et al. (2014) maintained that the central theme of Cognitive Load is the human cognitive architecture, specifically the limit of working memory, which should be considered when designing instruction. These researchers identified three types of Cognitive Load: intrinsic, extraneous, and germane cognitive load (Leppink et al., 2014). Both intrinsic and germane cognitive loads are similar in that they deal with relating information to existing schema.

Extraneous cognitive load is any information that has no relevance to the information being learned and gets in the way of learning. Therefore, the brain might filter the relevant information out (Wong, Leahy, Marcus, & Sweller, 2016). According to Van Merrienboer and Sweller (2005), CLT presumes that human working memory is limited and able to store up to seven elements; however, human working memory can operate on between two to four elements. Based on that assumption, those authors stated that it was vital to reduce extraneous cognitive load. CLT in multimedia should take this into consideration to maximize available cognitive resources for learning (Van Merrienboer & Sweller, 2005).

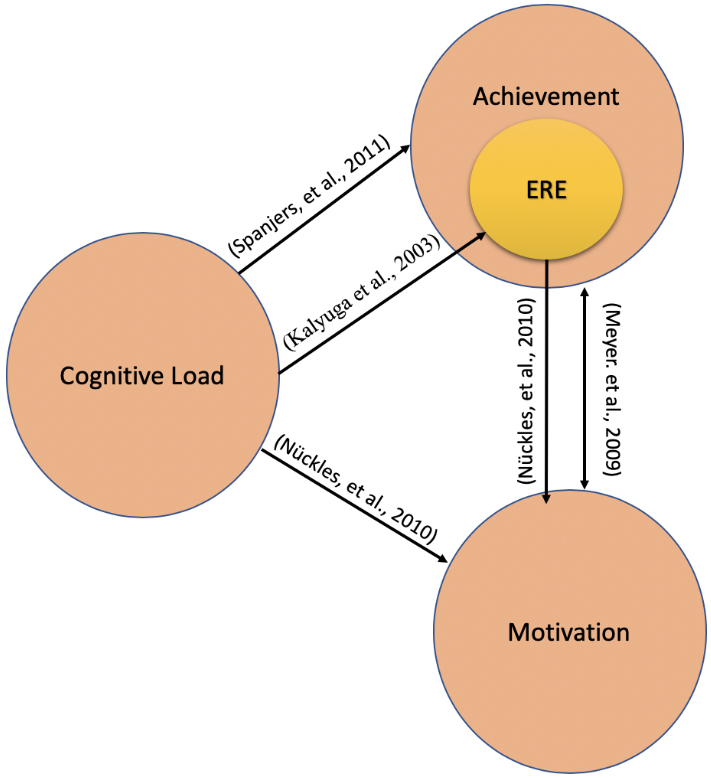
Mayer, Heiser, and Lonn (2001) listed three assumptions of cognitive theory of developing multimedia learning. The first is the dual channel assumption, which assumes people have two channels for processing information: visual (sight) and auditory (hearing). The second assumption is limited capacity; it presupposes a limit to the amount of input which human can handle in each channel at a time. The third assumption is active processing, in which people organize selected incoming information into manageable mental images, then combine those images with existing knowledge (Mayer, Heiser and Lonn (2001). These researchers designed four different instructional videos and showed them to students. The results showed that students responded best to the video that organized information well and did not include extraneous information which did not apply to the lesson being taught, but balanced germane and intrinsic cognitive load.

Cognitive Load and Achievement. Spanjers, et al., (2011) found that segmented, or sequential, graphics caused high cognitive load in expert learners. This resulted in an ERE effect for those students with higher experience. This was because dealing with information they already have knowledge of interfered with the efficiency of their instruction. Expert students had to reconcile information they already possessed with the instructional guidance, resulting in additional extraneous load.

Cognitive Load and Motivation. Nückles, Hübner, Düme and Renkl (2010) stated that ERE in expert students caused by high cognitive load also affected motivation. As students achieved learning outcomes and moved from novices to experts, dealing with information they were already familiar with resulted in high cognitive load. As in other studies, this created an expertise reversal effect. However, Nückles., et al, also noted a decrease in motivation with ERE. The researchers explained that students 'internal tendencies were decreased along with achievements (2010).

A study conducted by Spanjers, et al., (2011) showed that cognitive load could affect student achievement. Kalyuga, et al., (2003) stated that high cognitive load could cause an ERE effect with experienced learners when using sequential graphics. Nuckles, et al., (2010) noted that high cognitive load causing ERE could decrease learner motivation. Myer, et al., (2009) explained how student motivation and achievement could affect one another (see Figure 2).

Figure 2.
The Cognitive Load Effect on the Achievement and Motivation



Perceptual Load. Roper et al. (2013) showed when the environment was full of visual information, it was very difficult for the human brain to recognize and process all incoming information at once. The authors described perceptual load as the brain dealing with all the perceptual data, making choices on what data to attend to, and choosing which pieces of data to focus on over others to correctly interact with the environment. Additionally, the authors concluded that the perceptual load was important as it affected the overall focus of attention. This was determined by whether attention stayed highly focused or was divided among relevant items (Roper et al., 2013).

Lavie et al. (2004) found the amount of visual information that was disregarded depended on the perceptual load. The authors asserted that increasing perceptual load forces the brain to prioritize stimuli (information) into relevant and irrelevant categories. As a result, irrelevant brain stimuli are disregarded to allow a higher focus on relevant brain stimuli (Lavie et al., 2004). A research study conducted by De Fockert (2004) showed the irrelevant stimuli (distractors) were not completely disregarded, as the number of processed distractors during a higher perceptual load was dependent on the available working memory. This study was in agreement with studies which found more irrelevant stimuli could be processed with a higher working memory load (Rees, Frith, & Lavie, 1997).

Experience of learner. The level of learner's experience determines the effectiveness of instructional graphic; therefore, learner experience is a critical factor in designing instructional graphics (Kalyuga, Chandler, & Sweller, 2001). Kalyuga et al. explained the means that determine the most efficient method of information delivery, which may rely on the learner's experience (2001). They also stated that, when expert and novice learners are presented with the same information, the expert learners interpret the information more fluently than the novice learners. Experienced learners could draw on their existing knowledge to assist in learning new information from sequential graphics, while this type of graphics made comprehending information difficult and increased cognitive load for novice learners (Kalyuga et al, 2001).

As Kalyuga, Chandler, and Sweller (2000) explained, if learners have enough experience to understand a diagram, then text in any form, whether spoken, written, or both, is redundant and unnecessary for them to understand the information the diagram presents. Those researchers concluded that the best graphics format for experienced learners would be diagrams only with no text included (2000). The researchers also stated that if the learners did not have sufficient knowledge to understand the diagram alone, added text and spoken words were more beneficial rather than written text alone (Kalyuga et al., 2000).

Leow and Neo (2014) stated that multimedia can also affect learners' experience by giving them more choices. Additionally, those authors said that incorporating multimedia in the learning process allows the students to absorb the information more consistently and deeply. Leow and Neo went on to state that connecting students to a learning process by using multimedia does more than improve their ability to retain information and thereby expands their experience. It also improves learner attitudes and encourages them to be proactive in their education.

Expertise Reversal Effect. The expertise reversal effect (ERE) is observed when an instructional design element includes information that benefits novices but is not helpful for the expert learner (Kalyuga et al., 2003). Khacharem et al. (2013) found that ERE may occur when instructional material is presented in a form of dynamic graphics. This study found that the novice soccer players learned more about precise movements to execute a specific play from a sequential presentation than a concurrent presentation. However, the sequential presentation was more detrimental to the experienced soccer players (Khacharem et al., 2013).

Another experiment in ERE was performed by Rey and Fischer (2013) who presented introductory text and a computer program (the medium used to present the graphics) related to statistical data analyses. The researchers found the use of words as a supplement to animation was important for novice learners, but became redundant as the learner's expertise increased (2013). This study also concluded that providing additional words lowered test performance for experts when compared to experts who were not given the words to supplement the animation. Those researchers mentioned that the ERE happens "when learner's expertise moderates design principles derived from cognitive load theory" (p. 409).

Spanjers et al. (2011) found that animated graphics were effective in learning environment. However, learners' experiences affected how well they understood the presented information. The researchers stated that the learners with low experience benefitted from viewing the shorter segmented animations of a longer video, but the expertise reversal effect influenced the experienced learners and increased their cognitive load when viewing shorter segmented animations.

Summary

Conducted in an E-Learning environment, this study will utilize instructional multimedia presentations created using the multimedia principal to build simultaneous and sequential graphics. The ADDIE model will also be used as an instructional design model when creating the two types of video graphics. Through analyzing the data collected from CIS and tests, the researcher will be able to study the effect of simultaneous and sequential dynamic graphics on the achievement and motivation of engineering students of different experience levels. A study by Oz, et al., (2013) showed that sequential graphics improved student achievement and motivation. Additionally, the researcher will examine whether the sequential dynamic video causes the expertise reversal effect for experienced learners.

CHAPTER III

Method

This study utilizes a quasi-experimental research design, which will compare student achievement and motivation based up on learner expertise and type of dynamic graphic presented for undergraduate engineering students at a medium-sized university in Intermountain West. It will attempt to answer the six research questions listed in Chapter One. The goal of the study is to determine the effect of sequential and simultaneous dynamic video graphics on the motivation and achievement of learners of different levels of engineering education, novice and experts from freshmen to seniors.

Research Design

This research utilizes a quasi-experimental design. In a quasi-experimental research design, treatment conditions rely on natural circumstances rather than being randomly assigned by the researcher (Romanelli & Tushman, 1986). This study has both achievement and motivation as dependent variables. Besides the dependent variables, there are two independent variables, each with two levels. The first independent variable, graphic types, has sequential and simultaneous dynamic graphics as its levels. The second independent variable is learner expertise, also with two levels: expert and novice. In this study, a pair of repeated measures ANOVAs will test the effect of both graphic type and learners' experience level as well as their interaction effect on the students' achievement and motivation.

The research employed a quantitative, quasi-experimental research design utilizing four instruments. The first instrument was the pretest (see Appendix C) which the students answered in order to categorize them into expert or novice level students depending on their previous knowledge and their background. The second instrument was Keller's *Course Interest Survey*, which measured students' motivation. The third and fourth instruments were tests which measured student achievement.

Participants

The participants in this study were 80 undergraduate engineering students at a medium-sized university in Intermountain West. The students were from many different departments of engineering. They were enrolled in an online class. A brochure was emailed to everyone in the College of Engineering all faculty and students. The brochure explained the study and outlined the steps for participation.

The participants took a pretest (see Appendix C) which was used to divide them into two groups of learners, novice and expert. In the first week of the study, both groups viewed a sequential dynamic graphic presentation before completing the CIS then they took an achievement test. In the second week of the study, both groups viewed a simultaneous dynamic graphic presentation, then completed another CIS, and took a second achievement test (see Table 1).

Table 1.
Quasi-experimental Group Design for Achievement and Motivation

Pretest	Assignment	Treatment 1 Sequential Graphics	Motivation Survey (CIS)	Achievement Test	Treatment 2 Simultaneous Graphics	Motivation Survey (CIS)	Achievement Test
O_1	Expert	X_1	O_2	O_4	X_2	O_6	O_8
O_1	Novice	X_1	O_3	O_5	X_2	O_7	O_9

Note. X = Graphic type treatment O = Observation

Materials

The researcher designed two different types of videos to present information to the students; one with sequential dynamic graphics that outlined a step-by-step process and another with simultaneous dynamic graphics that presented the steps all at once. The design of these two videos, following the ADDIE model of instructional design, is presented in detail in Appendix I.

Blomberg, Renkl, Sherin, Borko, and Seidel (2013) stated that video examples are typically used in order to illustrate guidelines, which would help learners to understand that information in the proper context. The videos used in this study were presented to the students in order to help them to understand basic physics concepts and their relationship to a variety of mechanical engineering applications. Additionally, using videos in a learning environment has advantages beyond classroom instruction, rather than using only the textbooks to provide information for the students; they offer an interactive element since the learners can replay specific portions or fast forward to skip over sections that are already understood (Vieira, Lopes, & Soares, 2014).

The topics of videos for the experiment were friction and vector addition from an engineering statics course (see Appendix D). Vector addition was the topic for the sequential dynamic graphic condition. The friction video (see Appendix E) presented the information simultaneously. The researcher selected the topics to ensure that both of them were familiar to expert students since they had taken the Statics course as juniors.

However, friction and vector addition are not related in the steps of solving the test questions, so they are indirectly related to each other. The videos offered an information for the students, and avoided giving the students any information during watching the first video, that might have allowed them to expect the topic or the questions in the second video. In other words, both videos were informative, the topics and test questions were completely different, so the participants could not guess the content of one video after watching the other video. Although the videos were different in topic and presentation type as mentioned previously, the elements of the videos were the same in recording time period, graphics, colors, and narrator. The videos were uploaded to the course LMS Moodle, which allowed the learners to access the information as needed.

The videos in this experiment were designed to be just 5 minutes in length based on the findings of Guo, Kim and Rubin, which showed that shorter videos were better at holding students' attention (2014). In that study, shorter videos were found to be more engaging and increased achievement; additionally, students who watched the shorter videos were more inclined to answer post-video questions correctly (Guo et al., 2014).

Design. To design the videos, the researcher followed the five steps outlined by Blomberg et al. (2013) for designing the videos used in this study: (a) determining the goal or goals of the lesson, (b) using the videos as a tool, (c) deciding on an approach for integrating them into the class lessons, (d) choosing what kind of materials to use in making the videos, addressing any limitations that might be present, (e) incorporating the videos with the other existing instructional materials, so they not only meet the goals of the class, but also aligned with the learning assessment. When these steps are followed successfully, learner motivation is increased and the effectiveness of the videos are increased (Blomberg et al., 2013).

In this study, the researcher applied the ADDIE instructional design model, which consists of five phases: analysis, design, development, implementation, and evaluation. The first phase of analysis is the most important step in the process of instructional design (Morrison et.al., 2011). During this phase, the instructional content was defined in a way allows the designer to understand it from the learners' point of view. This phase corresponds with the first step of the Blomberg (2013) model in which the researcher determines the goals of the lesson. In the analysis phase, the researcher collaborated with a course instructor to determine the content and the desired outcome of the course. Additionally, the course instructor provided information to help the researcher understand the characteristics of the students.

The next step was the design phase. Morrison et.al. (2011) stated that presenting instructional ideas in the abstract makes it more difficult for learners to understand the materials. Therefore, presenting concrete or tangible ideas makes it easier for the learners to understand. This is the phase that relates to the third and fourth steps of the Blomberg model in which the researcher determines how the dynamic videos will be integrated into the class lessons and what kind of materials to use in making the videos. In designing the video presentations, the researcher made use of the information gained from working with the course instructor to make a plan that will make the course information concrete to the students. Examples of this type of planning include a storyboard for the instructional content and analysis tools.

The next phase in the ADDIE model is development, in which the materials are compiled into the instructional presentation. Morrison et.al. (2011) outlined the important elements of effective development including controlling the step size and pacing, so the learners won’t be overwhelmed with too much presented information at once. Furthermore, those authors stated that it is vital to maintain the consistency when presenting terms within the presentation. The videos used the same terminology consistently and included consistent spelling in the written text. In the development phase, the researcher incorporated these elements to create both video types using animated pictures with words.

The development phase was followed by implementation in ADDIE model. In this phase, the instruction was presented to the students. Implementation corresponds with Blomberg’s second step of using the videos as a tool. The fifth step also came into play with this phase, as it involves incorporating the videos with the other existing instructional materials, so they meet the goals of the class. The elements that are involved in this phase are: 1) making plans to present videos in the classroom and 2) determining what type of media equipment might be needed for the presentations (Morrison et.al., 2011). In this study, the presentation videos were available for the students to view online, posted on Moodle.

Evaluation is the last phase in the ADDIE Model. In this phase, the researcher determined whether the instruction successfully met the desired outcome of the course. The evaluation phase can determine whether the course requires improvement or adjustment to enhance its effectiveness (Morrison et.al., 2011). The type of evaluation for this study was a summative evaluation. Blomberg’s fifth step also corresponds with the evaluation phase of the ADDIE model because incorporating the videos with the other existing instructional materials involves making sure they align with learning assessment and evaluation.

The summative evaluation provided data that showed the outcome of the study and allowed the researcher to determine a conclusion for the research (Morrison et.al., 2011). The summative evaluation in this study took place after participants viewed all the videos and completed all the tests and the surveys. The results of the summative evaluation showed the main effect of the graphics types and the learners' expertise levels on the students' achievement and motivation. Additionally, it may show the interaction between video types and learners expertise on their achievement and motivation.

Instruments

The study made use of four instruments that were designed to measure student motivation or achievement (see Table 1). The first instrument was the pretest which subdivided the students into two groups; the novice group and the expert group. The second instrument was the Keller's *Course Interest Survey*. The survey was designed to measure students' motivation, and was used with each type of graphic. The survey was given twice, after each of the two types of videos were presented to the class. The third and fourth instruments were class tests, which were used to assess the students' achievement in class. Each test was administered after the motivation survey was given.

Pretest. The purpose of the pretest was to divide the students into two groups: expert and novice. It consisted of three sections. The first section asked two yes or no questions. The second section included five survey questions about their related to five statics topics so students would not be able to anticipate what topics would be covered in the videos. The third section included another five questions related to basic statics background. Expert and even intermediate students should be familiar with the information needed to answer the questions in section three correctly. Only novices would be unfamiliar with the information. The pretest was taken and submitted online.

CIS Survey. The Course Interest Survey (CIS) was based on Keller's original CIS (Keller & Subhiyah, 1993). The students took the CIS survey twice, once after each video presentation. It contained 34 statements that were rated on a five-point Likert scale ranging from strongly agree to strongly disagree. Students rated each statement on the scale that ranged from 1 (Strongly Disagree) to 5 (Strongly Agree) based on how much each student agreed with each statement. This scale allowed for a minimum score of 34 and a maximum score of 170 with a median score of 102. There were eight statements that applied each to the survey subscales of attention and confidence elements and there were nine statements that applied each to survey subscales relevance and satisfaction elements. The minimum, maximum, and midpoint scores varied for each of the subscales because there were different numbers of statement for each of them. What's more, seven of the 34 statement were reversed. The CIS Survey was taken and submitted online on Moodle (see Appendix F).

Reliability and Validity. Historically, Cronbach's alpha has been a benchmark for reliability and validity of Keller's CIS, as it has consistently scored above .80 for all four subcomponents of the ARCS, attention, relevance, confidence, and satisfaction (Gabrielle, 2003). For the purpose of this study, the CIS was placed in Moodle, the university's web-based format, similar to the web-based format of the CIS used by Gabrielle (2003). That study showed scores from the CIS in a web-based format that indicated a total reliability alpha of .81.

Class Tests. There will be two tests in this experiment. Each one will relate to the video topics, vector addition and friction. The tests will be given after the students complete the surveys. They will be multiple choice. The tests will contain twelve questions pertaining to various experience levels from basic to advance. They will also be taken and submitted online in Moodle.

Procedure

After dividing the students into two groups (novice and expert) using the first instrument, the pretest (see Appendix C), the videos were presented in class over a two-week period, one video (sequential video) in the first week (see Appendix D) and the second video (simultaneous video) the next week (see Appendix E). The second instrument, the Keller's Course Interest Survey (see Appendix F), was given to all participants after the videos presentation and before the class test. The survey was accessed online through Moodle. A remainder to answer the surveys were emailed to the students twice, once each time after they've viewed the videos and before they took the tests. The researcher organized the results placing the novice students' survey results in the novice category and the expert students' results in the expert category for analysis at the end of the experiment.

The third and fourth instruments were the cognitive tests to measure student achievement (see Appendixes G & H). The groups viewed graphic videos on different class topics, a sequential graphic (vector addition) and a simultaneous one (friction). The sequential video (see Appendix D) and the simultaneous video (see Appendix E) contained the same video display, speed, voice and color quality. Both videos were uploaded online and the students viewed them on google drive through the university Moodle.

The surveys and tests were given in the second and third weeks of the experiment. The students viewed the sequential graphics in the second week, then completed the first survey (see Appendix F) and took the first test (see Appendix G). In the third week, the same procedure was repeated. The simultaneous graphics were viewed before completing the second survey (see Appendix F) and taking the second test (see Appendix H). Finally, the researcher measured the achievement and the motivation between the expert and the novice groups after collecting the survey and test scores, then calculated the mean of each group.

Data Collection

Data on how the dynamic videos affect subjects' motivation was collected using Keller's CIS. The students completed the survey twice—once after each time that they viewed the two different videos. The surveys were available for students to fill out online using the university's Moodle system. Additionally, the researcher scheduled the surveys to be taken prior to the tests. This was done to minimize the effect of students' perception on how well they did on the tests on their motivation scores. The answers that the students gave in the surveys could not be right or wrong, so the surveys were unlikely to provide any additional information that might affect how well the students did on tests and were also unlikely to make them "test-wise." The surveys consisted of 34 questions and took approximately 15 minutes to complete. Achievement data was collected from the tests given after each CIS. Because the experiment was carried out using two different dynamic videos, two CIS, and two tests this was a repeated measure ANOVA design for both achievement and motivation.

Data Analysis

After completing all the tests of the quasi-experimental design, the achievement data will be analyzed in order to answer the research questions of this study. The researcher will analyze the data using a repeated-measures ANOVA with a between-groups factor – expertise. The design will test the main effect of both graphic types and learner experience level on the achievement of students. In addition, it will test the interaction effect between the graphic types and learner experience levels. If the interaction is present, it may confirm the presence an ERE.

A similar procedure will be used to determine the effect of dynamic graphic types on motivation. The students will complete the CIS to measure the main effects of graphic types on the student motivation. Besides studying the effect of the graphic types and the student expertise on the achievement, the data will show if there is an interaction between graphic types and students expertise.

Conclusion

This study is quantitative quasi-experimental design research. It has been structured to show the effect of sequential and simultaneous graphic videos on the learner experience level. The study includes four testing instruments designed to collect the data from engineering students in a medium-sized university in Intermountain West. The data was collected to study the students' achievement and motivation after dividing them into novice and expert groups. Finally, the repeated measures ANOVA was used to test the interaction of the graphic videos and learners' different experience levels, and their effect on the achievement and the motivation of the students, and if the ERE affected the collected data.

Chapter IV

Results

The purpose of this study was to determine the effectiveness of simultaneous and sequential dynamic graphics with learners of differing experience levels as a way to gain insight into how to achieve better results with all levels of students. Dynamic graphics were used because they can be designed to optimize learner understanding of the instructional message without overburdening cognitive systems. Sequential and simultaneous graphics were tested with novice and experienced learners in this study to determine the main effects of graphic type and experience level on the motivation and achievement of learners. Additionally, because some sequential graphics have an interaction effect with learners that may cause an expertise reversal effect (ERE) to occur, this research tested whether ERE occurred with the participants. A course interest survey (CIS) was completed by the students after viewing the different types of graphics to measure student motivation. The students' achievement was measured by scores on two unit tests that were given after completing both the unit and CIS survey.

Descriptive Statistics

The subjects in this study were engineering undergraduate students enrolled in College of Engineering courses at Idaho State University. Subjects ranged from freshmen to seniors. This study was conducted over a period of three weeks. The initial population consisted of 80, novice group (n = 42) expert group (n = 38). More detailed demographic information about the participants can be found in the participants subtopic of Chapter III.

The pretest consisted of three sections, with a total of 12 questions, designed to identify whether the participants were novices or experts (see Appendix C). Section A consisted of two questions, one confirming that the participants were students in the College of Engineering and the other determining how much experience they had in the textbook topics.

The five questions in Section B were designed to gather data from students regarding their confidence level. A 4-point Likert scale was used. Participants were required to rate all five statements as Strongly disagree, Disagree, Agree, or Strongly agree with no option for answering neutrally. The 4-point Likert scale forced the participants to examine whether they were confident or not. In this, they must decide whether they have at least some confidence in their ability or not. Additionally, a 4-point scale was used instead of a 6-point scale because this research explored the direction of each participant's confidence or lack of confidence rather than the amount of confidence (Worthen, White, Fan, & Sudweeks, 1999).

The final section, Section C, was made up of five problems based on engineering topics from the statics textbook. Two problems were on vector addition and friction, while the other three problems covered other engineering topics. Each question was multiple choice with four options. The questions were purposely designed not to reveal the answer.

This was done by identifying common mistakes and having those results available as an option. This was done so the students weren't able to guess the right answer from the way the question was worded. They had to know how to solve the problem in order to determine the right answer. In order to divide the students to two groups, the students who had taken a statics class classified as expert or novice depended on the instructions:

Six students who had taken a statics class and might have been classified as expert students, did not answer the questions in section C correctly, specifically the questions on vector addition and friction. They also did not indicate high confidence in Section B of the survey. Therefore, these students were classified as novices. Students who had taken a statics class but whose answers in the motivation section indicated low confidence would initially be classified as novices. However, answering three or more questions in section C correctly was sufficient to classify them as experts.

Students who had not taken a statics class and did not answer the questions in sections B and C correctly were classified as novices. This especially pertained to students who did not answer the vector addition and friction questions in section C correctly. Additionally, the one who indicated that they had low confidence to answer questions about friction and vector addition but who did answer those two specific questions correctly in section C had to be removed from the study due to conflicting information.

After analyzing the pretest data and dividing the students into two groups (novice and expert), the CIS survey was given to all participants after the video presentations and before the achievement test. The data from the study were collected and used to calculate descriptive statistics for the tests completed by the pretest and the two treatment groups. Means and standard deviations were computed for the scores on each test completed by the two treatment groups. The data for both groups and both assessments are shown in Table 2.

Table 2.
Means and Standard Deviation for Groups (experts and novice) and scores (cognitive tests and CIS surveys).

	M	*SD*	*N*
Achievement Tests			
Expert Group			
Test 1	9.21	2.35	
Test 2	7.39	3.13	38
Novice Group			
Test 1	8.07	3.02	
Test 2	6.07	3.49	42
Motivation Survey			
Expert Group			
CIS 1	125.08	15.39	
CIS 2	113.29	26.29	38
Novice Group			
CIS 1	116.62	20.92	
CIS 2	103.24	28.12	42

The data in Table 2 shows a difference of 1.14 points between the groups achievement in test one. The expert group mean scored higher than the novice group after viewing sequential graphics (9.21 - 8.07). Test two scores also showed a difference of 1.32 points between the groups. The expert group still scored higher than the novice group with mean scores (7.39 - 6.07). Each group showed improvement in test scores.

Also, the data in Table 2 show another difference between the groups motivation after first treatment of the study. The surveys revealed that the expert group's motivation was higher than the novice group after viewing sequential graphics (125.08 - 116.62). The scores after treatment two also showed a difference of 10.05 points between the groups and a reduction both groups' motivation; however, the expert group's motivation was still higher than that of the novice group (113.29 - 103.24). The surveys of the expert group showed higher motivation overall than the novice group.

Data analysis

The results of the study discussed beginning with Research Questions beginning with the first research question and its three sub-questions. All statistical data were analyzed using SPSS version 24 for MAC with a preset alpha of .05.

Research Question 1.

RQ 1 Do graphic types (sequential and simultaneous) and student expertise levels (novice or expert) have effects on student achievement in an engineering class as measured by class tests?

RQ1.1 Is there a statistically significant main effect of graphics type (sequential and simultaneous) on student achievement as measured by class tests?

Research Question 1.1 Hypotheses

H_0= There is no statistically significant main effect between the graphic types (sequential and simultaneous) on learner achievement.

H_1= There is a statistically significant main effect between the graphic types (sequential and simultaneous) on learner achievement.

To answer Research Question 1.1, data from achievement test and learner achievement relating to the graphic types effect were collected and analyzed by a repeated measures ANOVA with Expertise level as a between group factor. The results of the repeated-measures ANOVA resulted in F (1,78) = 19.17, P = .000. Since the observed probability was less than the α = .05, the difference in mean test scores on the simultaneous (M = 13.46, SD = 6.62) and sequential graphics (M = 17.28 SD = 5.37) were statistically significant. It should be noted that the effect size was η^2 = .197 which was a large effect (Myers, Well, & Lorch, 2010).Therefore, this study found that the participants scored statistically significantly higher on the unit test used for sequential graphics than with simultaneous graphics. This result will be further discussed in Chapter V.

Research Question 1.2

RQ1.2 Is there a main effect of student expertise levels on student achievement in engineering class as measured by class tests?

Research Question1. 2 Hypotheses

H_0= There is no statistically significant main effect between the learner expertise level (novice and expert) on learner achievement.

H_1= There is a statistically significant main effect between the learner expertise level (novice and expert) on learner achievement.

To answer the research question 1.2, data from achievement test and learner achievement relating to the learner expertise effect were collected and analyzed. The repeated-measures ANOVA resulted in F (1, 78) = 5.50, P = .021, η^2 = .066. The difference in mean test scores after viewing simultaneous and sequential graphics were statistically significant since the observed probability was less than the α =.05. The effect size was η^2 = .066 which was a large effect (Myers et al., 2010). Overall, the results showed that the expert participants scored statistically significantly higher on the unit test used for both conditions of graphics (M = 16.6, SD = 5.48) than the novice group (M = 14.14, SD = 6.51). This result will be further discussed in Chapter 5.

Research Question 1.3

RQ1.3 Is there an interaction effect between graphic types (sequential and simultaneous) and student expertise (novice or expert) on student achievement in engineering class as measured by class tests.

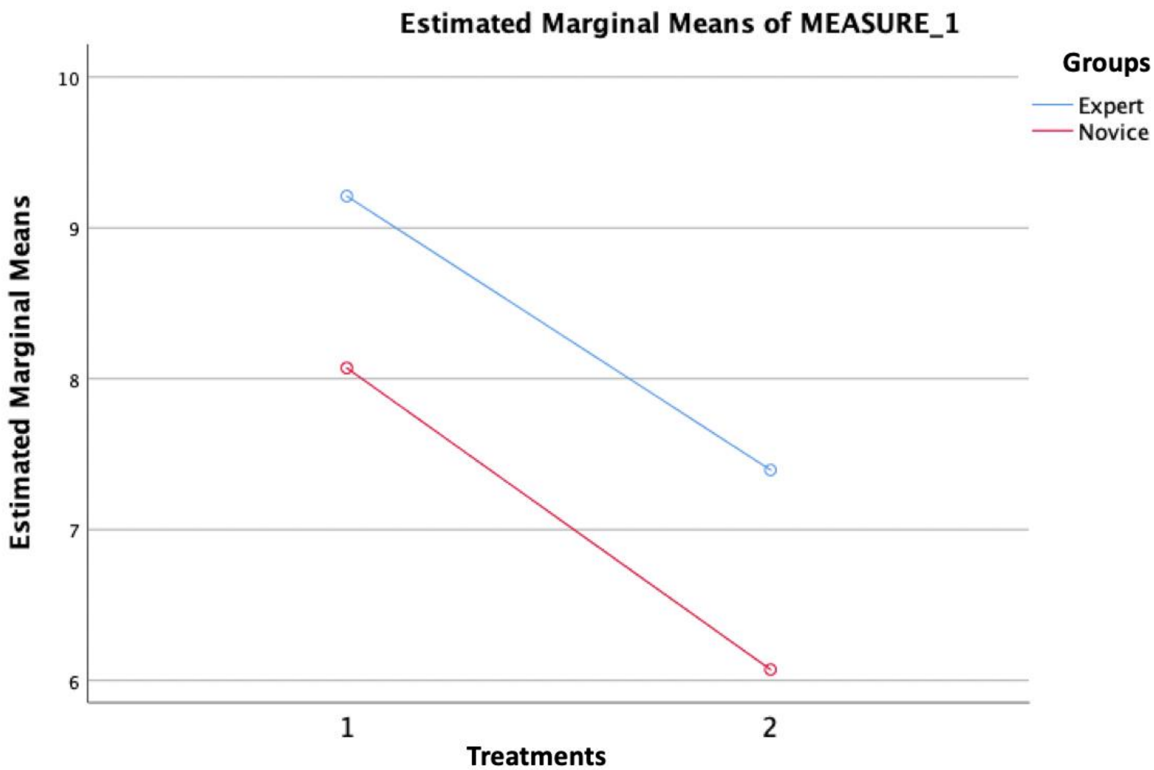
Research Question 1.3 Hypotheses

H_0= There is no statistically significant interaction effect between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner achievement.

H_1= There is statistically significant interaction effect between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner achievement.

The interaction between the graphic types and the learner's expertise level was not statistically significant F (1, 78) =. 045, P = .833, η^2 = .001, observed power=.055 (see figure 3). The observed means and standard deviations were; expert-sequential graphic (M = 9.21, SD = 2.35), expert-simultaneous graphic (M = 7.39, SD = 3.13), novice-sequential graphic (M = 8.07, SD = 3.02), novice-simultaneous graphic (M = 6.07, SD = 3.49).

Figure 3.
The Mean Tests Scores for Each Combination of Groups of "Graphic Types" and "Learner's Expertise Level".



These data shown in Figure 3 indicates that both groups scored well after viewing simultaneous graphics, but not as well as after viewing the sequential graphics. As expected, the expert group scored higher on both tests than the novice group. Additionally, these data show that there was no ERE found in this study.

Research Question 2

RQ 2 Do graphic types (sequential and simultaneous) and student expertise levels (novice or expert) have effects on motivation in an engineering class as measured by Keller's *Course Interest Survey*?

RQ2.1 Is there a main effect of graphic types (sequential and simultaneous) on student motivation on engineering class as measured by Keller's *Course Interest Survey*.

Research Question 2.1 Hypotheses

H_0= There is no statistically significant main effect between the graphic types (sequential and simultaneous) on learner motivation.

H_1= There is a statistically significant main effect between the graphic types (sequential and simultaneous) on learner motivation.

The answer for research question 2.1 was found by gathering data from cognitive tests and learner motivation in relation to graphic types and effect. A repeated measures ANOVA was used to analyze the data and the expertise level was considered a between-group factor. Applying the repeated-measures ANOVA resulted in F (1, 78) =24.76, P = .000. Since the observed probability was less than the α = .05, the difference in mean survey scores on the simultaneous (M = 216.58, SD = 54.41) and sequential graphics (M = 241.7, SD = 36.34) were statistically significant.

Additionally, the observed probability was less than the α = .05. Therefore, there was a statistically significant difference in mean survey scores on the simultaneous and sequential graphics. It should be noted that the effect size was large: η^2 = .24 (Myers et al., 2010). Consequently, this study found that participants CIS survey means were significantly higher for sequential graphics than simultaneous graphics. Chapter 5 will explore this result in more detail.

Research Question 2.2

RQ2.2 Is there a main effect of student expertise (novice or expert) on student motivation on engineering class as measured by Keller's *Course Interest Survey*.

Research Question 2.2 Hypotheses

H_0= There is no statistically significant main effect between the learner expertise level novice and expert) on learner motivation.

H_1= There is a statistically significant main effect between the learner expertise level (novice and expert) on learner motivation.

To answer research question 2.2, survey data were collected after students watched the sequential video about the vector addition topic in the first treatment and the simultaneous video about the friction topic in the second treatment. This data were used to measure if the different graphic types had an effect on learner motivation.

Applying the repeated-measures ANOVA resulted in F (1, 78) = 4.11, P = .04, η^2 = .05. The probability was less than α =.05, revealing a statistically significant difference in scores after viewing simultaneous and sequential graphics. Additionally, it should be taken into consideration that the effect size was η^2 = .050, a notably large effect (Myers et al., 2010). The results showed a statistically significant difference in scores after viewing the two graphic types. The expert participants scored statistically significantly higher on the CIS survey for both graphics conditions (M = 238.37, SD = 41.68) than the novice group (M = 219.86, SD = 49.04). This result will be further discussed in Chapter 5.

Research Question 2.3

RQ2.3 Is there an interaction effect between graphic types (sequential and simultaneous) and student expertise levels (novice or expert) on student motivation on engineering class as measured by Keller's *Course Interest Survey*.

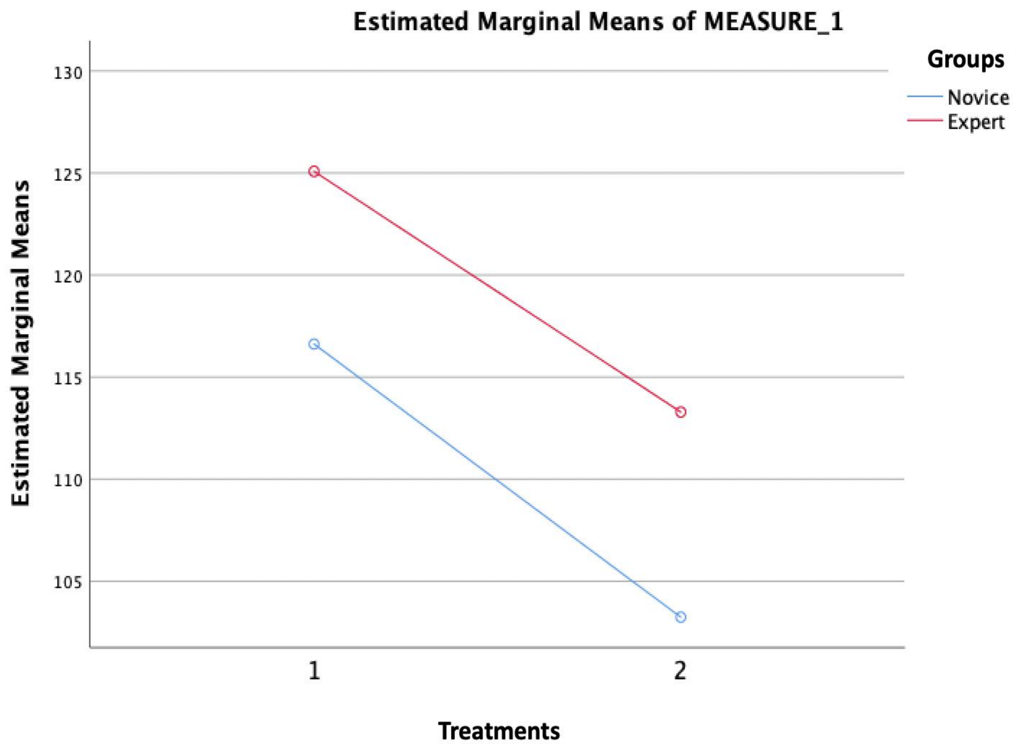
Research Question 2.3 Hypotheses

H_0= There is no statistically significant interaction effect between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner motivation.

H_1= There is statistically significant interaction effect between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner motivation.

The interaction between the graphic types and the learners experience level was not statistically significant F (1, 78) = .099, P = .75, η^2 = .001, observed power=.06 (see figure 4). The observed means and standard deviations were: expert-sequential graphic (M = 125.08, SD = 15.39), expert-simultaneous graphic (M = 113.29, SD = 26.29), novice-sequential graphic (M = 116.62, SD = 20.92), novice-simultaneous graphic (M = 103.24, SD = 28.12).

Figure 4.
The Mean Survey Scores for Each Combination of Groups of "Graphic Types" and "Learners' Expertise level".



These data shown in figure 4 indicate that both groups' motivation increased after viewing simultaneous graphics, but not as much as after viewing the sequential graphics. Additionally, these data show that there was no ERE found in this study. Further analysis was obtained by looking at the CIS four survey subscale: attention, relevance, confidence and satisfaction (see Chapter V).

Conclusion

This study found that there was a statistically significant effect of graphic types on learner achievement and motivation. This was shown through achievement test scores and CIS survey scores favoring sequential graphics over vector addition and simultaneous graphic on friction. Also, this study found that there was a statistically significant effect of learner expertise level, favoring experts on learner achievement and motivation. This was shown through achievement test scores and CIS survey scores using sequential graphic on vector addition and simultaneous graphic on friction. The achievement tests scores and CIS surveys scores on sequential graphic on vector addition and simultaneous graphic on friction showed that there is no statistically significant interaction effect between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner achievement and motivation.

Chapter V

Conclusions

This study was designed to determine the effectiveness in using both simultaneous and sequential dynamic graphics with learners of differing experience levels. The students in this study viewed both types of dynamic graphics in the university's Moodle system. The study was designed to see the main effect between each type of graphics and the learner expertise level on the motivation and achievements as well as to determine the best ways to design multimedia instruction.

Discussion of findings

Research question 1 examined the main effects of graphic type and learner experience on learner achievements, as well as whether there is an ERE caused by an interaction effect between graphic types and learner experience on learner achievements. This study answered research question 1.1 by showing that there was a statistically significant main effect of graphic types on learner achievement. Since the observed probability was less than the $p = .05$, the difference in main test scores on the simultaneous and sequential graphics were statistically significant. The most direct interpretation of this result is that sequential graphics led to greater learning outcomes than simultaneous graphics. However, since the two topics were not the same, there is the possibility of a confounding effect between the topics and the graphic types.

According to the results of this study, both groups of students seemed to benefit from viewing both types of graphics with the sequential graphics leading to higher scores. This outcome supports previous research that showed that students achieved better learning outcomes from multimedia, making it a valuable tool for encouraging student achievement (Mayer & Sims, 1994). Additionally, research by Oz, et al., (2013) also showed that sequential animations help students' achievement and motivation. This research also parallels studies such as Giorgetti's, that showed multimedia is a useful tool to accomplish specific outcomes (2006). The results also indicated that the sequential graphics were effective for both groups. The cognitive theory of multimedia learning states that segmenting helps learners understand information better because it allows learners to fully understand each part of a system or concept before moving on to the next step (Spanjers et al., 2011). Previous studies showed that learners who viewed segmented lessons performed better on transfer tests than learners who viewed unsegmented lessons (Mayer, 2008).

Addressing research question 1.2, this study found that there was a statistically significant main effect of learner experience level on learner achievement. As expected, the participants with more engineering expertise scored higher across the cognitive measures than the novices. This is mostly due to the fact that the experts had more content knowledge than the novices as measured by the pretest. Oz, et al., (2013), the researchers found that sequential animation supported students achievement. This supports earlier studies that found that learner experience level determines the effectiveness of instructional graphics (Kalyuga, Chandler, & Sweller, 2001), making learner experience a critical factor in designing instructional graphics to optimize possibilities of effectively meeting class achievement goals.

The test for research question 1.3 showed that there was no statistically significant interaction effect between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner achievement. Therefore, the simplest interpretation of this result is that the treatments affected both groups in similar fashion. This lack of significant results could be due to the small sample in this study (N = 80).

The students' background and prior knowledge could also have an effect on their achievement. Since the subjects in this study were engineering students, they may have higher cognitive load capacity than students with other majors. Additionally, engineering students of all experience levels may have a different way of perceiving and understanding information from different types of graphics that could affect their scores. Engineering students have a deeper background of mathematics and physics science than many other students in the university. This also could explain the absence of ERE because basic engineering classes depend on students understanding detailed step-by-step processes.

The findings in this research do not support previous studies such as Spanjers et al. (2011) that found that simultaneous graphics have an interaction with learner experience and causes an expertise reversal effect. In this study, no interaction effect between the graphic types and the learner experience on the learner's achievement or no ERE occurred.

Research question 2 examined learners' motivation and included three sub-questions. Research question 2.1 examined the main effect of graphic type on learner motivation. The results of this study showed that there was a statistically significant main effect of graphic type on learner motivation. A direct interpretation of this result would be that sequential graphics led to greater motivation than simultaneous graphics. However, presenting different topics with each type of graphic complicate the interpretation of these motivation results. It may be that because the vector addition topic is a less complex topic than the fraction topic, presenting it using any graphic type would have resulted in higher scores. More research should be done presenting a more equivalent topic with sequential graphics to show whether sequential graphics benefit students learning topics of varying difficulty.

Using graphics in general could be one of the reasons for higher motivation in the subjects. It could be that graphics capture and hold student attention better. Also, students may be able to organize information delivery better with graphics. The relatively high cognitive test scores in this study showed that students benefitted from both types of graphics, which may be related to motivation.

Research question 2.2 examined the main effect of learner experience level on learner motivation. This study found that there was a statistically significant main effect of learners' experience level on their motivation. Since the CIS survey measures Keller's ARCS model, with the "C" in ARCS representing "confidence," it seems likely that experts would be more confident than the novices. One of the questions used to sort novices and experts asked about their confidence. Therefore, students with higher confidence were more likely to have higher confidence. Since confidence is a subscale of the CIS this might account for the differences in CIS motivation scores fevering experts. The individual CIS subscales will be further discussed later in this chapter. Thus, the experts may have scored higher on the overall CIS score due to higher scores on the confidence subscale.

The video length could be another factor in the increased motivation in this study. The videos were purposely designed with similar short lengths (5 minutes) with the possible effect on motivation in mind. In previous research, ERE was shown to occur with high cognitive load. The researcher in this study designed the videos with a short length to reduce chances that the learners would dismiss information due to a lengthy presentation.

Engineering students were subjects of this study. The topics of the videos in this experiment should have been familiar to the subjects. Therefore, they may have been more motivated than students in other majors might have been. Motivation could have been affected differently if applied to non-engineering students as well.

Research question 2.3 also examined whether interaction effect between graphic types and learner experience on learner motivation might cause ERE. The CIS survey scores from weeks one (sequential graphic) and week two (simultaneous graphic) showed that there is no statistically significant interaction effect between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner motivation. Therefore, the simplest interpretation of this result is that the videos affected the subjects in a similar way. The length of the videos could be one reason that there was no ERE. The researcher purposely designed both videos (sequential and simultaneous) with a similar short length (5 minutes), so perhaps the videos were not so long as to increase cognitive load and cause ERE. Short videos take less time to view, have generally fewer concepts, and may not overload cognitive resources. This is in line with a study by Kalyuga & Renkl that showed high cognitive load resulted in ERE (2010).

Additionally, the small sample size (N = 80) of this study may have affected the results concerning ERE, and may have shown different results if a larger sample had been used. Furthermore, the subjects of this study were all engineering students. It's possible ERE would have occurred if applied on non-engineering students as well.

Additional Analysis

Further analysis was obtained by looking at the CIS four survey subscales: attention, relevance, confidence and satisfaction (see Table 3). Because no ERE evidence was found and there was no evidence of difference in cognitive load patterns caused by the materials. Additionally, there was no evidence of difference in overall motivation patterns caused by the materials; therefore, the subscales of the motivation instrument might show different patterns of results.

Table 3.
Means and Means Difference for Groups (experts and novice) and scores CIS Surveys Subscales Scores (attention, relevance, confidence and satisfaction).

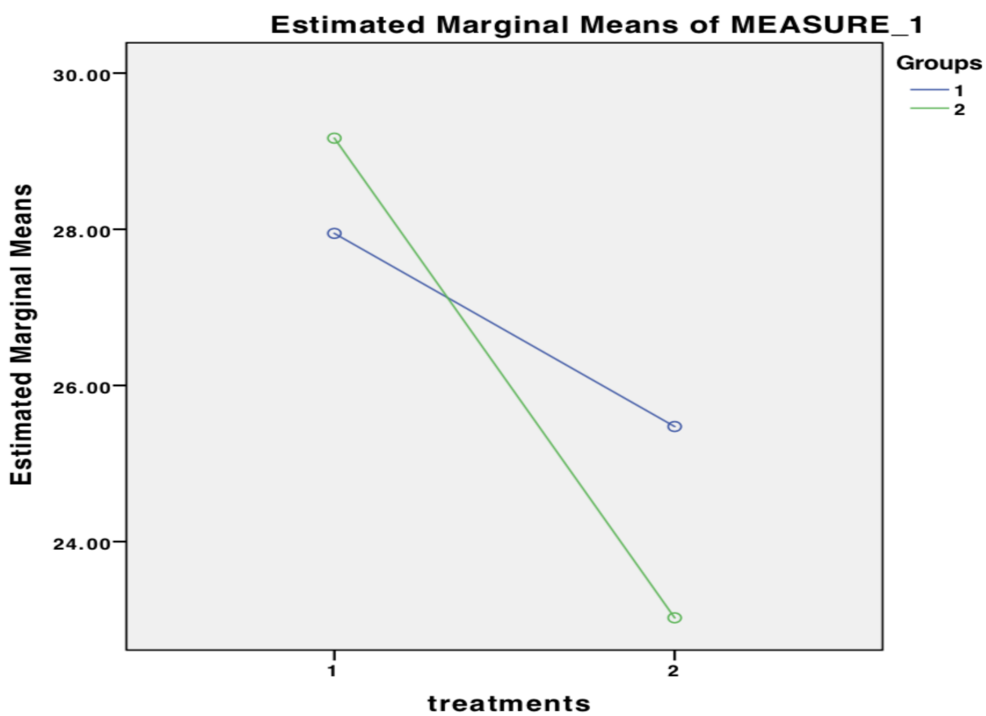
Motivation Test	Experts	Novices	Difference
Treatment 1	125.08	116.62	8.46
Treatment 2	113.29	103.24	10.05
Difference	11.79	13.38	
Attention subscale	**Experts**	**Novices**	
Treatment 1	27.95	29.17	-1.22
Treatment 2	25.47	23.02	2.45
Difference	2.48	6.15	
Relevance subscale	**Experts**	**Novices**	
Treatment 1	34.92	30.17	4.75
Treatment 2	30.89	28.14	2.75
Difference	4.03	3.31	
Confidence subscale	**Experts**	**Novices**	
Treatment 1	30.45	25.64	4.81
Treatment 2	27.87	24.43	3.44
Difference	2.58	1.21	
Satisfaction subscale	**Experts**	**Novices**	
Treatment 1	31.76	31.64	0.12
Treatment 2	29.05	27.64	1.41
Difference	2.71	4.00	

The data in Table 3 display differences in motivation and motivation subscales between the groups after each treatment in the study. The overall CIS survey scores revealed that the expert group's motivation was higher after viewing sequential graphics than the novice group (125.08 to 116.62). The motivation scores from treatment two also showed a difference of (10.05) points between the groups and a decrease in both groups' motivation; however, the expert group's motivation was still higher than that of the novice group (113.29 to 103.24). The surveys of the expert group showed higher motivation in general than the novice group.

The data revealed that the expert group's attention subscale score was lower than the novice group's score after viewing the sequential graphic treatment (27.95 – 29.17). It showed a difference of (-1.22) points between the groups with novices having a higher attention main scores than experts in after treatment one and a reduction both groups' attention after treatment two; however, after treatment two the expert group's attention higher than that of the novice group (25.47 – 23.02). There was a difference of (2.45) points between the groups. The differences in the novices' CIS scores after treatments one and two show that their attention was higher when viewing the sequential graphics video, which could be one factor in novices' higher motivation with the sequential graphics than the simultaneous graphics.

A repeated measures ANOVA was used to analyze the data and the expertise level was considered a between-group factor. Applying this test resulted in F (1, 78) = 28.54, P = .000. This is for the main effect of the graphics types. The observed probability was less than the α = .05; therefore, there was a statistically significant difference in mean attention subscale scores on the simultaneous and sequential graphics. It should be noted that the effect size was large: η^2 = .268 (Myers et al., 2010). Applying the repeated-measures ANOVA resulted in F (1, 78) = .21, P = .065, η^2 = .003 for the learner expertise level. The probability was larger than α =.05 revealing no significant difference in learner expertise level scores after viewing simultaneous and sequential graphics. The interaction effect between the graphic types and the learners expertise level was statistically significant F (1, 78) = 5.17, P = .026, η^2 = .062 (see Figure 5). This will be discussed in “Discussion of the CIS subscale comparisons” section.

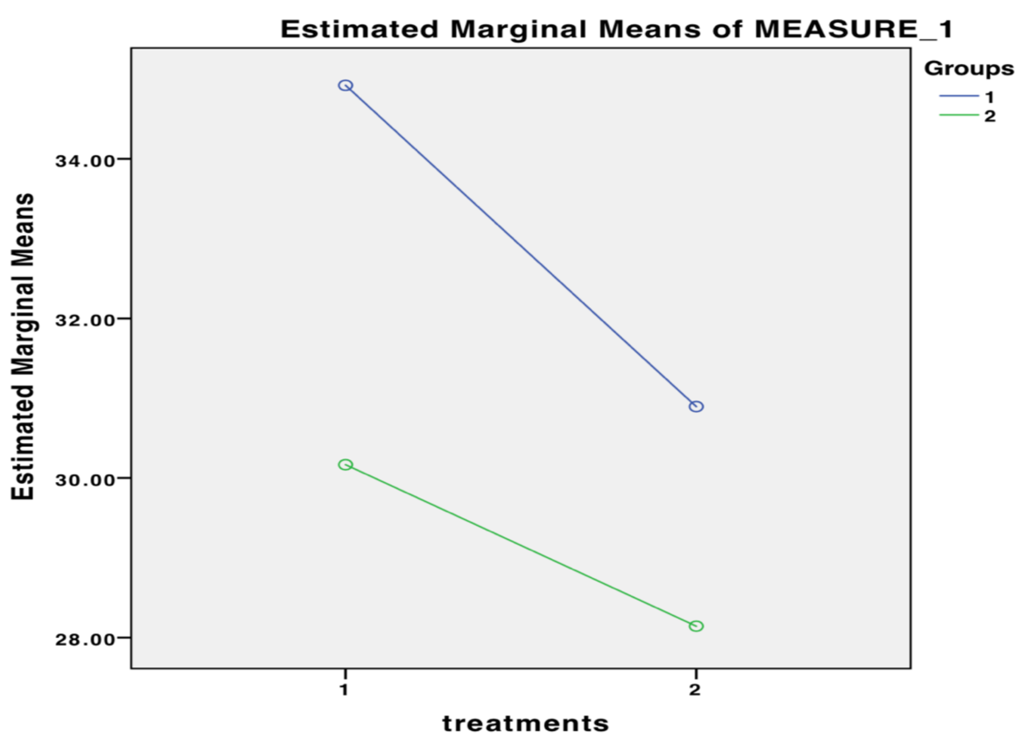
Figure 5.
The Mean of Attention Subscale Scores for Each Combination of Groups of "Graphic Types" and "Learners Expertise Level".



The surveys scores for the relevance subscale score was higher for the expert group than the novice group after viewing sequential graphics treatment (34.92- 30.17). It showed a difference of (4.75) points between the groups and a reduction in relevance for both groups; however, relevance subscale score after the treatment two remained higher for the expert group than that of the novice group (30.89 – 28.14).). It showed a difference of (2.75) points between the groups. The differences in both groups CIS scores after treatments one and two show that relevance was higher when viewing the sequential graphics video on vector addition.

A repeated measures ANOVA was used to analyze the data and the expertise level was considered a between-group factor. Applying this test resulted in F (1, 78) = 10.89, P = .001 for the main effect of graphics types. The observed probability was less than the α= .05. Therefore, there was a statistically significant difference in main relevance subscale scores on the simultaneous and sequential graphics. It should be noted that the effect size was medium: η^2 = .122 (Myers et al., 2010). Applying the repeated-measures ANOVA resulted in F (1, 78) = 7.84, P = .006, η^2 = .09 for learner expertise level. The probability was less than α = .05, revealing a statistically significant difference in learner expertise scores after viewing simultaneous and sequential graphics. The interaction between the graphic types and the learners expertise level was not statistically significant F (1, 78) = 1.19, P = .278, η^2 = .015 (see Figure 6). This will be discussed in “Discussion of the CIS subscale comparisons” section.

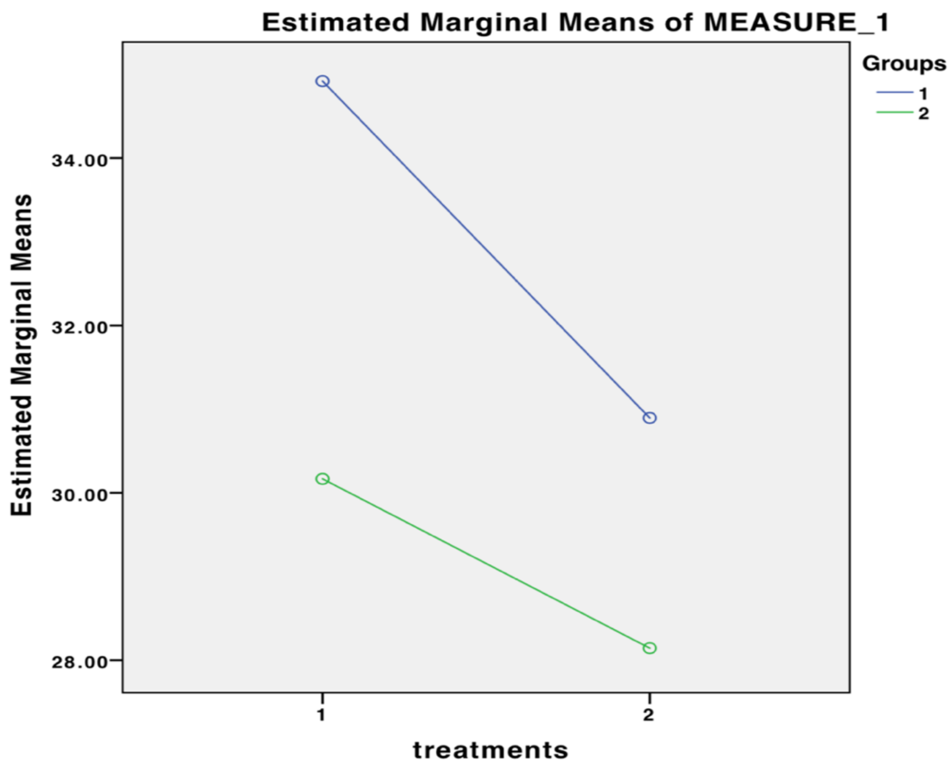
Figure 6.
The Mean of relevance Subscale Scores for Each Combination of Groups of "Graphic Types" and "Learners Expertise Level".



The confidence subscale revealed that the expert group's confidence subscale score was higher than the novice group after viewing the sequential graphics treatment (30.45 - 25.64). It showed a difference of (4.81) points between the groups and a reduction both groups' confidence; however, after treatment two the expert group's confidence was higher than that of the novice group (27.87 - 24.43). It showed a difference of (3.44) points between the groups. The differences in the experts' CIS scores after viewing treatment one and two show that their confidence subscale score was consistently higher than the novices when viewing the either type.

A repeated-measures ANOVA was applied and resulted in F (1, 78) = 10.87, P = .001. This is for the main effect of graphic types. The observed probability was less than the α = .05. Therefore, there was a statistically significant difference in mean confidence subscale scores on the simultaneous and sequential graphics. It should be noted that the effect size was medium: η^2 = .122 (Myers et al., 2010). The repeated-measures ANOVA resulted in F (1, 78) = 13.64, P = .000, η^2 = .149 for the learners expertise level. The probability was less than α =.05, revealing a statistically significant difference in learner expertise scores after viewing simultaneous and sequential graphics. The interaction between the graphic types and the learners expertise level was not statistically significant F (1, 78) = 1.41, P = .239, η^2 = .018 (see Figure 7). This will be discussed in "Discussion of the CIS subscale comparisons" section.

Figure 7.
The Mean of confidence Subscale Scores for Each Combination of Groups of "Graphic Types" and "Learners Expertise Level".

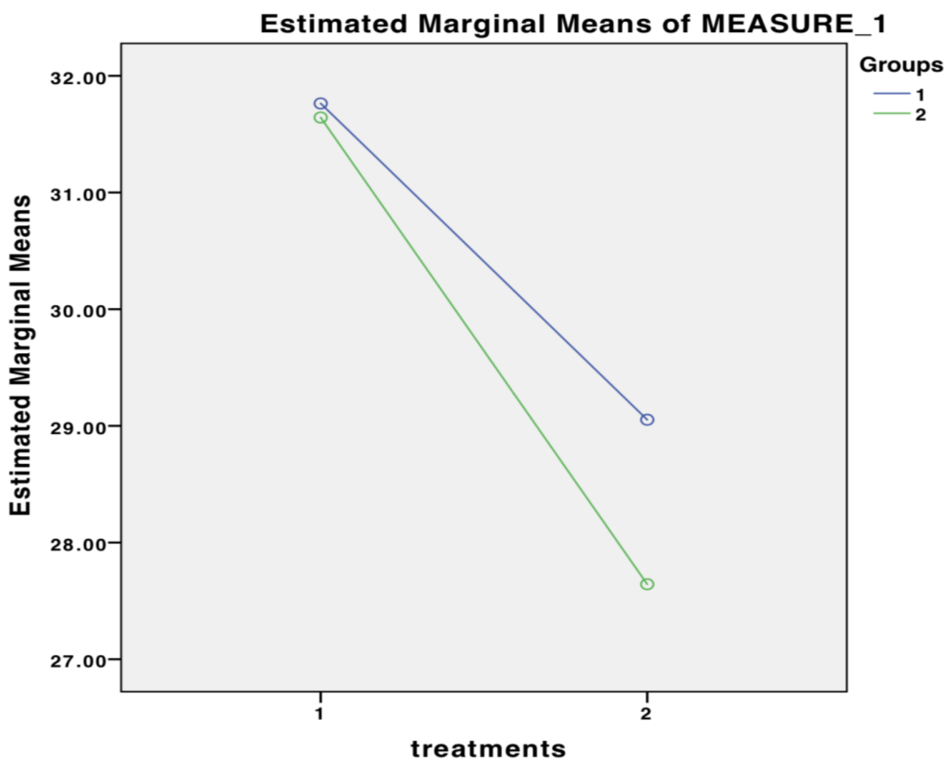


The survey results measuring satisfaction indicated the expert group's satisfaction was similar to the novice group after viewing sequential graphics treatment (31.76 - 31.64). It showed a difference of (0.12) points between the groups and a reduction both groups' satisfaction; however, after viewing the second treatment, although both groups' scores dropped, the expert group's satisfaction was higher than that of the novice group (29.06 - 27.64). There was a difference of (1.41) points between the groups after treatment two. The differences in the groups' CIS scores after treatment one and two shows that their satisfaction was higher when viewing the sequential graphics video on vector addition.

These data were subjected to a repeated measures ANOVA with expertise level as the between groups factor. It is resulted in F (1, 78) = 12.30, P = .001. This is for the graphic types.

The observed probability was less than the α = .05. Therefore, there was a statistically significant difference in mean satisfaction subscale scores on the simultaneous and sequential graphics treatments. The effect size was large: $\eta^2 = .136$ (Myers et al., 2010). Also, this teat resulted in $F(1, 78) = .377$, $P = .541$, $\eta^2 = .005$. This is for the learner expertise level. The probability was larger than α =.05, revealing not statistically significant difference in learner expertise scores after viewing simultaneous and sequential graphics. The interaction between the graphic types and the learners expertise level was not statistically significant $F(1, 78) = .454$, $P = .502$, $\eta^2 = .006$ (see Figure 8). This will be discussed in "Discussion of the CIS subscale comparisons" section.

Figure 8.
The Mean of satisfaction Subscale Scores for Each Combination of Groups of "Graphic Types" and "Learners Expertise Level".



Discussion of the CIS subscale comparisons

The experts' overall CIS scores dropped (11.79) points after treatments one and two. This could be due to the combination of graphic type treatments (sequential and simultaneous) or topics (vector addition and friction). When examining the subscales, the experts' drop in motivation score after viewing both of the treatments was found in attention (2.48), relevance (4.03), confidence (2.58), and satisfaction (2.71). For the novices' the CIS overall scores dropped (13.38) points from treatment one to treatment two. The subscales demonstrate that the largest drop in experts' motivation subscale score was found in relevance (4.03) and confidence (2.58). In relevance subscale, there was a difference of (4.75) points after treatment one and (2.75) points between the groups after treatment two. Additionally, there was a difference of (4.81) points after treatment one and (3.44) points in confidence subscale between the groups after treatment two. However, when examining the subscales, the largest portions of the novices' drop in motivation subscale score was found in attention (6.15) and satisfaction (4.00).

When examining the relevance subscale, the outcome of the experts scores after viewing treatment one could be attributed to the way in which the graphics were designed making it easy for students in both groups to relate the information to their individual prior experience and knowledge, making the graphics relevant to novices and experts. After treatment two, the experts could be more likely to be upperclassmen. It could be because they are more likely to be taking classes in the specialty field of engineering (e.g., electrical engineering), which doesn't include the study of friction and thus is not relevant to them.

Under the subscale of confidence, experts could have more experience with the topics in the videos than the novices. This could be due to the video design, the topic, or a combination of both. The first treatment video presented the information sequentially and resulted in higher scores for both groups than the second treatment video, which presented more information simultaneously. Another explanation could be the simultaneous graphic topic (friction) was more difficult than the sequential graphic topic (vector addition). Additionally, it should be noted that the pretest design focused in part on measuring students' confidence as a way to divide the students into expert and novice groups. The pretest measured them as experts because of their own indications through the answers stating their confidence in their experience with engineering topics. This could be another factor in the difference between the experts' higher confidence in general.

Additionally, the subscales show that the largest portions of the novices' drop in motivation was found in attention (6.15) and satisfaction (4.00). In attention subscale, there was a difference of (-1.22) points in after treatment one and (2.45) points between the groups after treatment two. This could be because giving novices small amounts of information in sequential steps gets more of their attention. The decrease in attention after treatment two could be because of the combination of more information in simultaneous graphics and difficulty of the topic.

Finally, there was a difference of (0.12) points in satisfaction after treatment one and (1.41) points after treatment two favoring experts. This could be because in the first video treatment presented the topic in sequential small pieces that were understandable. The students may have been more satisfied after the sequential graphic treatment than when the second treatment was presented in one piece with the simultaneous video.

Recommendations for future research

Recommendations for future researched are based on suggesting alternative research to expand on the results of or avoid the limitations of this study. The specific findings of this research could possibly be due to the small sample of subjects (N = 80) used in this study, with the expert group (n = 38) and the novice group (n = 42). The recommendation for future studies is to use larger groups of students overall, increasing both the number of expert and novice students.

The participants of this study were engineering students of varying expertise levels. Future studies could use sequential and simultaneous graphics with both engineering and non-engineering students to determine if participants' major has an effect on the cognitive test scores.

The simultaneous graphics used in this study may not have had a level of complexity significant enough to cause a high cognitive load. Another study could repeat this experiment with more complex simultaneous graphics to increase the learners' cognitive load. One theory on ERE is related to the level of cognitive load generated in the learners (Kalyuga & Renkl, 2010). Such a study would address this theory.

Another consideration should be the topics used with graphic types in this study. The results achieved could have been due to sequential graphics being used for the friction topic and simultaneous graphics being used for the vector addition topic. A future study should examine using topics of equivalent complexity with both types of graphics.

The fact that only engineering students participated in this study rather than a diverse cross-section of students may have something to do with the lack of ERE. Perhaps the study of engineering prepared students for step-by-step procedures that prevented the simultaneous graphics from causing an ERE.

Effects of video length should also be studied further. While short, 5-minute instructional videos proved effective for improving learner achievement and motivation for engineering students in this study, longer videos may improve those results even further. However, there is the chance that longer videos may increase cognitive load which could interfere with achievement and motivation. Applying different lengths of videos in future studies will show whether the video length has a positive or negative affect, or possibly no different effect than the results this study showed.

The length of the treatment design in this study was brief, two weeks, and could be extended. Researchers could design and apply the treatment over the course of a full semester. Extending the length of the study will allow researchers to see if similar results are achieved when presenting students with additional information through extra videos. Moreover, increasing the length of the study could determine if achievement and motivation are affected even more by viewing additional videos of each type.

Recommendations for future practice

The findings of this study suggest that learner motivation and achievement can be positively affected through designing instructional materials using graphics to present information. Because no ERE occurred in this study, instructional designers should be able to use sequential and simultaneous graphics, as needed, when designing instructional materials. Designers should be able to confidently apply either type of graphic to an engineering topic without fear of ERE occurring.

The results of this study indicate that sequential graphics lead to higher achievement and motivation scores than simultaneous graphics. The recommendation for future practice based on this study's results is that designers can select sequential graphics in their design over simultaneous. This in agreement with Clark and Meyer who found that segmenting information could help students learn (2016).

Summary

The results of this research study found that there was no statistically significant interaction effect (ERE) between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner motivation. Further analysis explored was earned four CIS survey subscales: attention, relevance, confidence and satisfaction. The subscales revealed that the largest drop in experts' motivation subscale score was found in relevance (4.03) and confidence (2.58). Additionally, the subscales showed that the largest portions of the novices' drop in motivation was found in attention (6.15) and satisfaction (4.00). It should be noted that there was a statistically significant interaction effect (ERE) between the graphic types (sequential and simultaneous) and the learner expertise level (novice and expert) on learner attention.

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Appendix A

The Study Brochure

ENGINEERING STUDENTS:

WE ARE ASKING YOU TO PARTICIPATE IN A STUDY OFFERED TO ENGINEERING DEPARTMENT STUDENTS AT IDAHO STATE UNIVERSITY.

The purpose of this research is to study learning with graphic visualizations and their relationship to expertise level with engineering students. The tests and surveys in this study will measure students' 'background in statics, attitude toward the graphics, and understanding of some static concepts.

THE PROCESS WILL BE:

First week:
1. You will take the pretest, which should take about 10 minutes.

Second week:
1. View one video on Moodle (approx. 5 minutes).
2. Answer the survey (15 minutes).
3. Complete the test (15 minutes).

Third week:
1. View one video on Moodle (approx. 5 minutes).
2. Answer the survey (15 minutes).
3. Complete the test (15 minutes).

TO PARTICIPATE IN THIS STUDY

1- GO TO THE MOODLE SITE AND SIGN IN USING YOUR ISU USERNAME AND PASSWORD.

2- ENTER "GRAPHIC TYPES STUDY" IN THE SEARCH FIELD.

3- THE SYSTEM WILL ASK YOU TO ENTER A KEY CODE. ENTER (graphics) IN THE SPACE PROVIDED.
THIS WILL ENROLL YOU IN THE STUDY.

PARTICIPANTS WHO COMPLETE ALL PORTIONS OF THE STUDY AND DATA COLLECTIONS WILL BE ENTERED INTO A DRAWING FOR ONE OF 45 GIFT CARDS WITH $15, $20, $25.

ARTICIPATION IN THIS STUDY IS COMPLETELY VOLUNTARY AND YOU MAY WITHDRAW AT ANY TIME.

FOR FURTHER INFORMATION REGARDING THIS RESEARCH PLEASE CONTACT DR. DAVID COFFLAND, AT: COFFDAVI@ISU.EDU

Appendix B

The Consent Form

Consent Form

Dear Participant:

We are asking you to complete a survey being given to engineering department students in Idaho State University. The purpose of this research is to study graphic visualizations and their relationship to expertise level with engineering students. The tests and surveys in this study will measure students' background in statics, attitude toward the graphics, and understanding of some static's concepts. The assessment will take place after viewing videos with different graphic visualizations. It is our hope that information from this experiment will contribute to a better understanding of the effectiveness of graphics for engineering student in ISU.

The tests taken during this study are entirely for research purposes and will NOT affect your grade for any course. Your responses to the research tests and surveys will be anonymous. Your name will be removed from the collected materials for this study. No report will include names of participants or any individual score information.

Participation in this study is completely voluntary and you may withdraw at any time. Participants who complete all portions of the study and data collections will be entered into a drawing for one of 45 gift cards.

For further information regarding this research please contact Dr. David Coffland, email**:** **coffdavi@isu.edu**

If you have any questions about your rights as a research participant you may contact human subject committee chare, Dr. Ralph Baergen (208)-282-3371 or at humsubj@isu.edu.

Please confirm your agreement to participate in this study by clicking the "Yes, I agree to participate in this stud" at the button of this page.

I am 18 years or older and have read and understood this consent form and agree to participate.

___ Yes, I agree to participate in this stud.

___ No, I do NOT wish my data to be used in this study.

Appendix C

The Pretest

Pretest

Section A

1. Are you a student in the college of engineering?

a) Yes b) No

2. Have you taken the engineering statics class CE 2210?

a) Yes b) No

Section B

1- I feel confident that I can solve problems using dot products.

a) Strongly disagree b) Disagree c) Agree d) Strongly agree

2- I am concerned that I may have difficulty in solving friction problems.

b) Strongly disagree b) Disagree c) Agree d) Strongly agree

3- I feel confident that I can solve problems using the vector addition.

a) Strongly disagree b) Disagree c) Agree d) Strongly agree

4- I am concerned that I may have a difficulty in solving problems with moments.

a) Strongly disagree b) Disagree c) Agree d) Strongly agree

5- I feel confident that I can solve problems using Newton’s second law.

a) Strongly disagree b) Disagree c) Agree d) Strongly agree

Section C

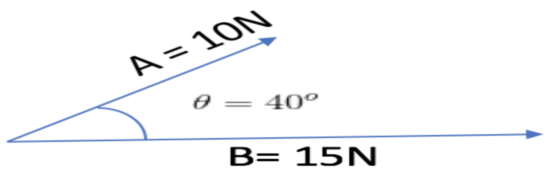
1- What is the dot product of vector A and vector B?

a) 150 cos40^o

b) 150 sin40

c) $\frac{15}{10}\cos 40$

d) $\frac{15}{10}\sin 40$



2- A force of 20 N at an angle of 25^o acts upon a 2 kg object. The acceleration of the object is:

a) 10 m/s^2 at angle of 75°

b) 10 m/s^2 at angle of 25°

c) 40 m/s^2 at angle of 75°

d) 40 m/s^2 at angle of 25°

3- A person A uses a 1m lever to lift a rock, A person B uses a 2m lever to lift the same rock. The force of person B is what compared to person A's force if they have the moment:

a) Half as much force.

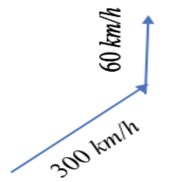
b) Twice as much force.

c) One forth as much force.

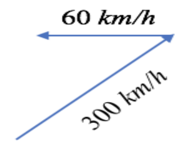
d) Four times as much force.

4- Which diagram displays the vector presentation for an airplane travelling at 300 *km/h* at an angle of 45º with a wind velocity of 60 *km/h* at an angle of 90º.

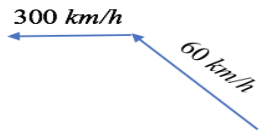
a)



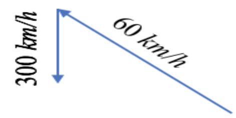
b)



c)



d)



5- If a block of 4 *kg* mass has a maximum static friction of 16 *N* on a surface, the kinetic friction coefficient is:

a) 0.4

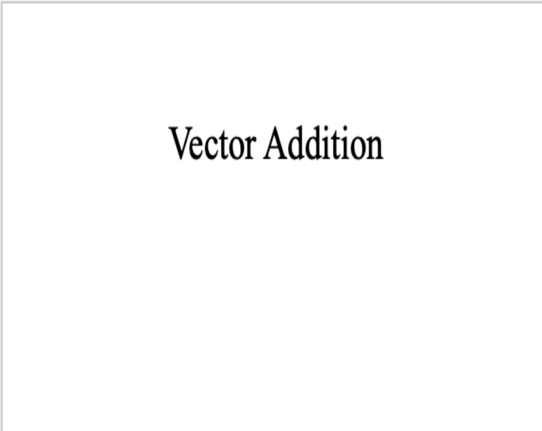
b) 0.6

c) 2.5

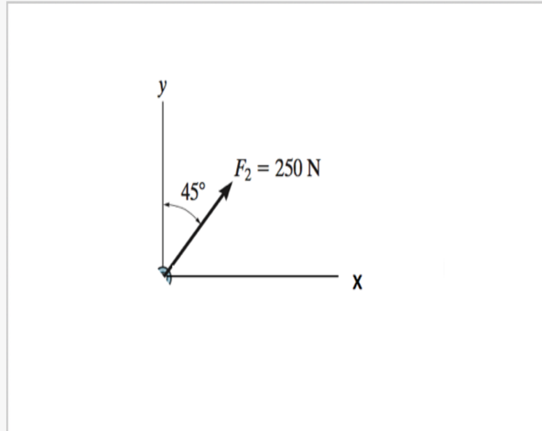
d) 16

Appendix D

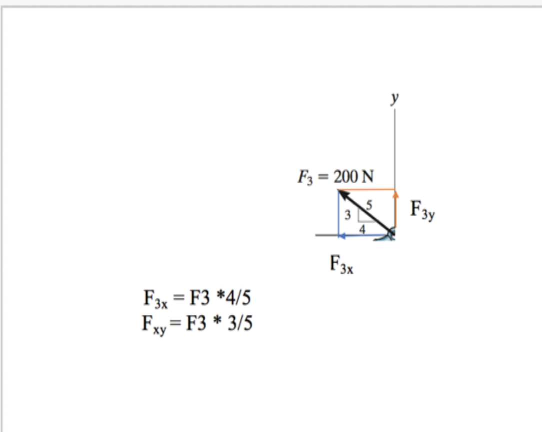
Slides Used to Develop Week 1 Video


Vector Addition

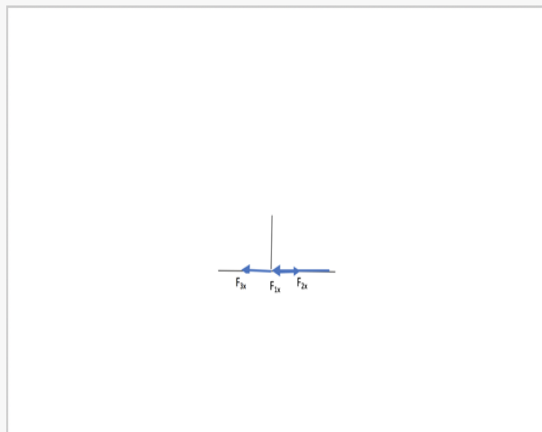
1


y
$F_2 = 250$ N
45°
x

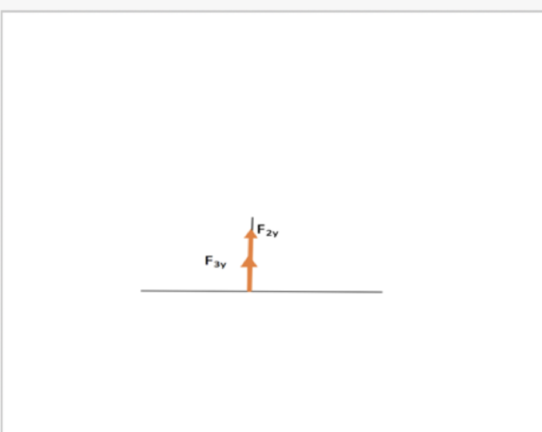
2


y
$F_3 = 200$ N
5
3
4
F_{3y}
F_{3x}
$F_{3x} = F3 * 4/5$
$F_{xy} = F3 * 3/5$

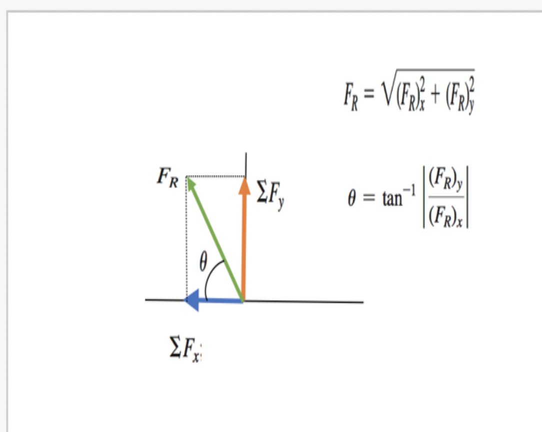
3



4


F_{2y}
F_{3y}

5


$F_R = \sqrt{(F_R)_x^2 + (F_R)_y^2}$
F_R
ΣF_y
$\theta = \tan^{-1}\left|\frac{(F_R)_y}{(F_R)_x}\right|$
θ
ΣF_x

6

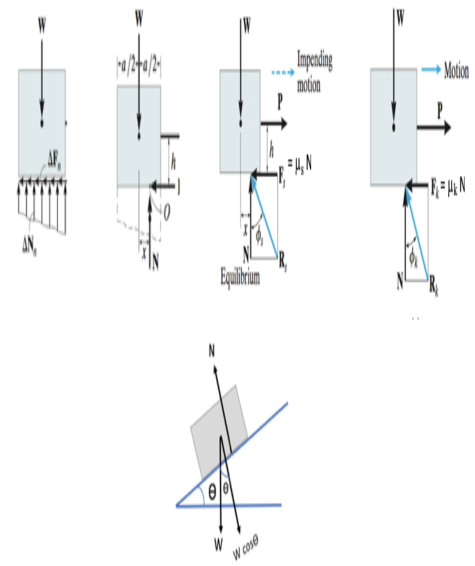
Appendix E

Slides Used to Develop Week 2 Video

Friction

1

Friction



2

Appendix F

CIS Surveys Week 1 and 2

	Strongly agree	Agree	Neutral	Disagree	strongly agree
1. The video makes me feel enthusiastic about the subject matter of this course.					
2. The things I learned from the video will be useful to me.					
3. What I learned from the video makes me feel confident that I will do well in this course.					
4. The content of the video captured my attention.					
5. The video design makes the subject matter seem useful.					
6. I feel confident I will do well on the test.					
7. I have to work too hard to understand the video content.					
8. I do NOT see how the content of the video relates to anything I already know.					
9. How well I do on the test is up to me.					
10. I found the design of the video exciting.					
11. The subject matter of video is just too difficult for me.					
12. I feel satisfied with the information I learned from the video.					
13. In this course, I try to set and achieve high standards of excellence.					
14. I feel that my experience level is equal to the video content.					

15. My curiosity level was stimulated by the subject matter in the video.					
16. I enjoy participating in this course.					
17. It is difficult to predict what grade I will get on the test.					
18. I am pleased with how well I understood the video content compared to how well I expected to understand it.					
19. I feel satisfied with what I am learning from the video.					
20. The content of this video relates to my expectations and knowledge.					
21. The video contains unusual or surprising things that are interesting.					
22. I enjoy actively participating in this course.					
23. To do well on the test, it is important that I understand the video content.					
24. The instructor uses an interesting variety of video tools on this topic.					
25. I do NOT feel I will benefit much from this course.					
26. I could NOT focus on the video content.					
27. I believe that I can achieve a good grade if I work hard enough.					
28. The personal benefits of the video content are clear to me.					
29. My curiosity was stimulated by the subject matter in the video.					

30. I find the challenge level presented by the video was neither too easy not too hard.					
31. I feel rather disappointed after watching the video.					
32. I feel that I get enough recognition of my work by understanding the video content.					
33. The amount of information presented in the video was appropriate for my experience level.					
34. I gained confidence from understanding the video content.					

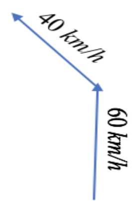
Appendix G

Achievement Test 1

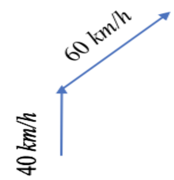
Test Week 1

1. **A car is driven with a velocity of 60 *km/h* north, then the car merged by exit 64 with a velocity of 40 *km/h* north west. Which figure presents the velocities of the car from beginning of the trip until it merged?**

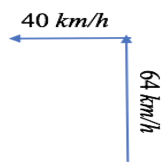
a)



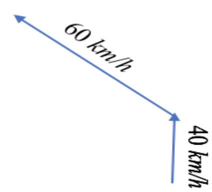
b)



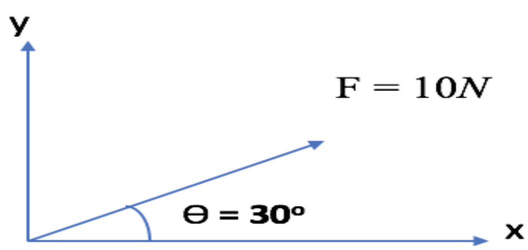
c)



d)



Use the figure below to answer question 2, 3.



2. What is the magnitude of F_x for the force (F)?

a) 7.07 *N*

b) 5.00 *N*

c) 8.66 *N*

d) 10.00 *N*

3. What is the magnitude of F_y for the force (F)?

a) 7.07 *N*

b) 5.00 *N*

c) 8.66 *N*

d) 10.00 *N*

4. If the horizontal of a force is 4 *N*, and its vertical is 3 *N*, what is the magnitude of the force:

a) 5 *N*

b) 4 *N*

c) 3 *N*

d) 6 *N*

5. In question 4, the direction of the force is

a) 41°

b) 37°

c) 49°

d) 53°

Use the figure below to answer question 6,7,8.

6. The equation to calculate the resultant force is:

a) $\sqrt{F_1 + F_2}$

b) $\sqrt{F_1^2 + F_2^2}$

c) $F_1 + F_2$

d) $F_1 - F_2$

7. The magnitude of the resultant force is:

a) 5 *N*

b) 10 *N*

c) 15 *N*

d) 25 *N*

8. What is the final direction of motion for the object?

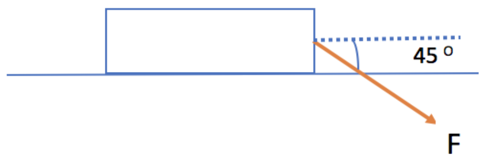
a) In the positive x direction.

b) In the negative y direction.

c) In the negative x direction

d) Does not move

9. If the force acts on the object as shown in the figure, which of the flowing option is true?



a) The magnitude of the vertical component of the force *F* is zero.

b) The magnitude of the vertical component of the force *F* is *F* sin45.

c) The magnitude of the vertical component of the force *F* is –*F* sin45.

d) The magnitude of the vertical force is the same as *F*.

10. The resultant force of adding two vectors, perpendicular to each other, is:

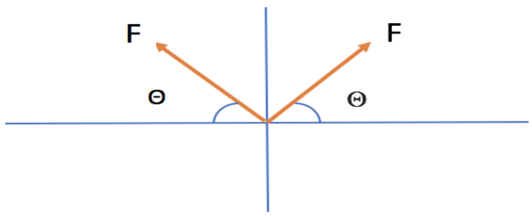
a) F_1+F_2

b) $\sqrt{F_1 + F_2}$

c) $\sqrt{F_1^2 + F_2^2}$

d) $F_1^2 + F_2^2$

Depending on the figure, answer question 11,12.



11. The addition of x-components of the forces in the figure is?

a) $2F$

b) $F/2$.

c) $\sqrt{F^2}$

d) Zero

12. The sum of the two forces in the figure is:

a) $2F$.

b) $F/2$.

c) $\sqrt{F^2}$

d) $2\ F \sin \Theta$

Appendix H

Achievement Test 2

Test 2

1. **Static friction appears when:**

   a) The object is in motion on a surface.

   b) The object is stationary on a surface.

   c) The object is in motion in general.

   d) The object is equilibrium.

2. **Kinetic friction appears when:**

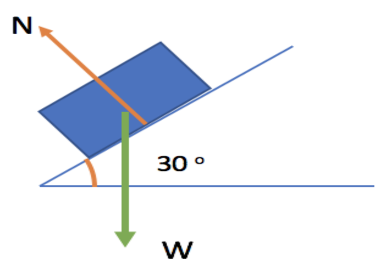
   a) The object is in motion on a surface.

   b) The object is stationary on a surface.

   c) The object is in motion in general.

   d) The object is equilibrium.

Use the figure below to answer questions 3 and 4. Use g = 9.8 m/s^2, μ_s = 0.7, m = 5 kg, and μ_k = 0.3.



3. **Calculate the static friction for the object.**

   a) 29.7 *N*

   b) 17.2 *N*

   c) 25.4 *N*

   d) 20.4 *N*

4. What is the magnitude of the kinetic friction force?

a) 35.7 *N*

b) 13.2 *N*

c) 12.7 *N*

d) 25.4 *N*

5. In equilibrium, the normal force always:

a) Acts upward to balance the object weight.

b) Acts downward since it is the weight.

c) Act horizontally to move the object.

d) Act horizontally to resist movement.

6. An object moves with low velocity a cross horizontal service and is about to stop under kinetic friction 50 *N*, if the mass of the object is 7 *kg*, the static friction coefficient is:

a) 0.73

b) 0.60

c) 0.70

d) 0.65

7. Which statement is true?

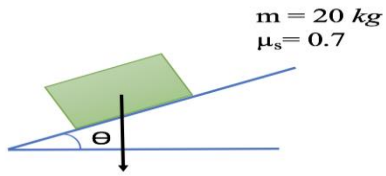
a) Both the friction and normal forces are evenly distributed.

b) Both the friction and normal forces are unevenly distributed.

c) Friction is evenly distributed and the normal force is unevenly distributed.

d) Friction is unevenly distributed and the normal force is evenly distributed.

The figure shows a stationary object on an inclined plane. Use the figure below to answer questions 8 – 12. Use g = 9.8 m/s².



8. **The expression for the normal force is:**

a) $mg\sin\theta$

b) $mg\cos\theta$

c) $mg\tan\theta$

d) $mg\cot\theta$

9. **The expression representing the static friction force is:**

a) $mg\sin\theta$

b) $mg\cos\theta$

c) $mg\tan\theta$

d) $mg\cot\theta$

10. **At what angle will the object start to slide?**

a) 30º

b) 35º

c) 40º

d) 45º

11. The magnitude of the normal force is

a) 150 *N*

b) 161 *N*

c) 165 *N*

d) 155 *N*

12. The static friction coefficient in this example can be directly calculated using:

a) $\cos\theta$

b) $\cot\theta$

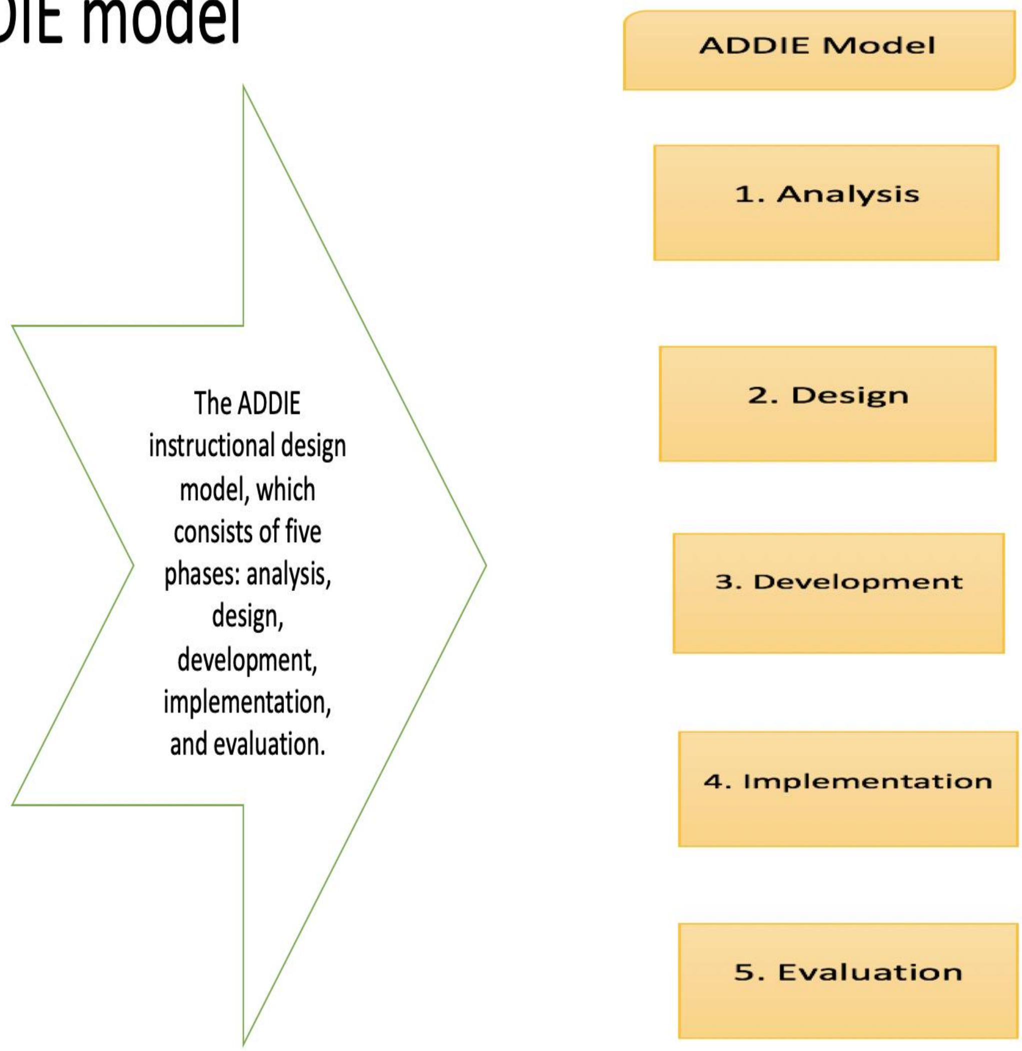
c) $\tan\theta$

d) $\sin\theta$

Appendix I

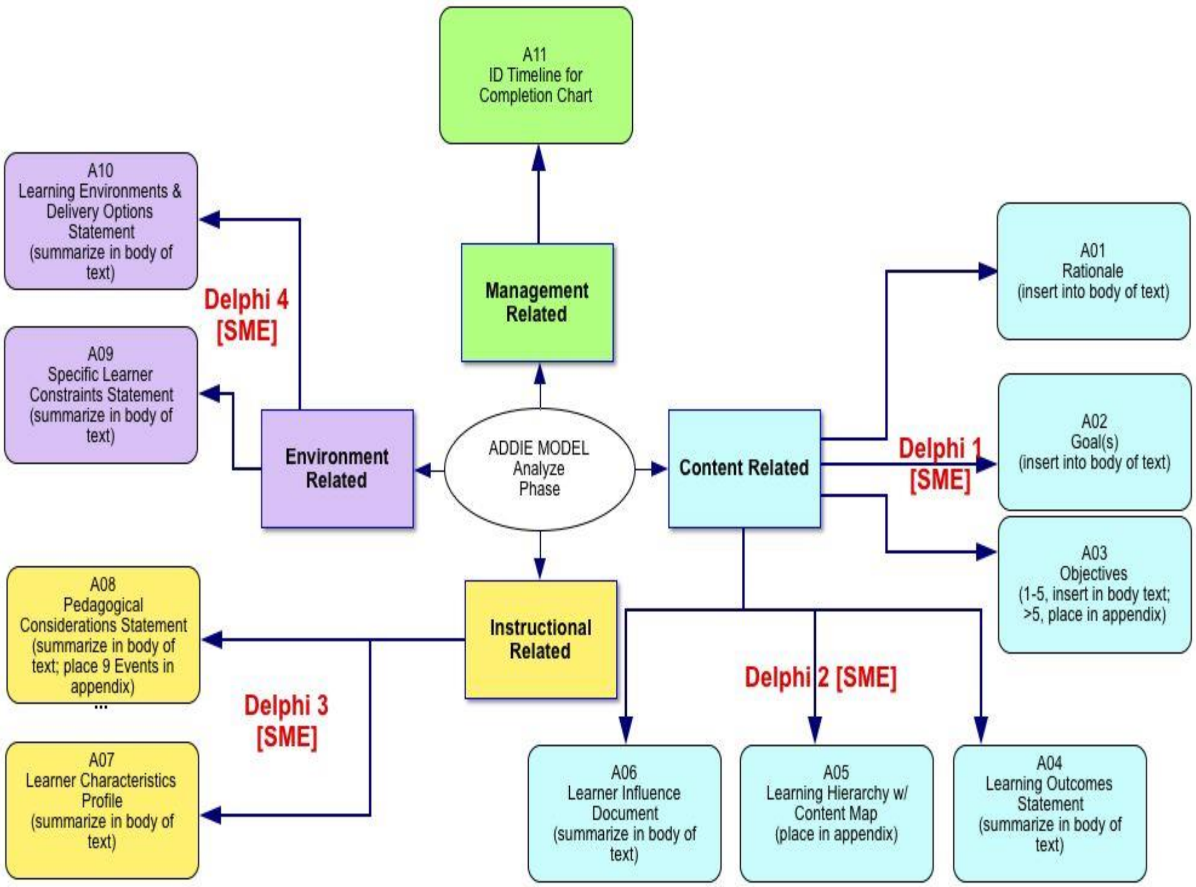
The ADDIE Model Phases

ADDIE model


The ADDIE instructional design model, which consists of five phases: analysis, design, development, implementation, and evaluation.
ADDIE Model
1. Analysis
2. Design
3. Development
4. Implementation
5. Evaluation

Appendix G

14 Steps of ADDIE Analysis



Strickland et al. (2013)

Appendix K

ADDIE Analysis Phase Tasks A01, A02, and A03

Guidelines: Rationale/Goal/Objectives/Outcomes

Rationale

Existing research has shown that dynamic graphics are beneficial for helping learners understand new concepts and procedures. Different types of dynamic graphics can be used in learning environments. Sequential and simultaneous graphics are two examples. Both are effective for helping students learn. However, is one type better than another for optimizing achievement and motivation in students?

This study was designed to determine the effectiveness in using both simultaneous and sequential dynamic graphics with learners of differing experience levels. It will also show the main effect between each type of graphics and the learner expertise level on the motivation and achievements. The results will help instructional designers to create lessons that will be most useful for teaching students of all experience.

Goals

Goal. The goal of this study is to determine the effectiveness of the two types of graphics on learner achievement and motivation. It will also help instructional designers to choose the best way to present information to students. Additionally, it will show the effectiveness of different learner experience on how they perceive the graphic types.

Objectives

1- Given the consent form and pretest, the engineering students will mark answers which will identify which of the two groups they belong: experts and novices.

2- Presented with the sequential graphic video, the engineering students will complete a survey and a cognitive test which will determine the effectiveness of sequential graphics on learner motivation and achievement.

3- Presented with the simultaneous graphic video, the engineering students will complete a survey and a cognitive test which will determine the effectiveness of simultaneous graphics on learner motivation and achievement.

Appendix L

ADDIE Analyze Phase Task A08

Consideration	Response	Revisions to Response
Physical Age Range:	18 to maybe older than 50	
Educational Range:	Undergraduate engineering students (freshmen to senior)	
Cognitive Range:	Novice and experts	
Prerequisite Knowledge/Skills:	No prerequisite	
Group Dynamics:	Students are from three different engineering departments: civil, mechanical, and electrical engineering. The class is online and does not meet in person.	
Learning Style Preferences:	unknown	
Motivational Factors:	Motivation among the subjects is average. At a minimum, they are motivated to learn information and concepts that will further their engineering knowledge.	
Attitudinal Factors:	Life distractions are common. Things such as personal problems, social relationships, fatigue, health, and overall academic responsibilities.	
Environmental Factors:	As an online learning environment, the students receive support in a friendly, encouraging manner to minimize overwhelm.	

Appendix M

ADDIE Analyze Phase Tasks A09 and A11

Target Audience Statement

The target audience for this study will be the under rate engineering students (freshmen to senior level).

ADDIE Analyze Phase Task A10

Pedagogical Considerations

The subjects in this study are undergraduate engineering students with prior computer and Moodle experience. They are able to read and write sufficiently to navigate the Moodle system and complete the surveys and tests. Because they are engineering students they may have background or prior knowledge in the video topics.

Appendix N

ADDIE Design Phase Task D01

Task Analysis

Task/Subtask	Knowledge Type (**D, P, S**)	Prerequisite (**Y/N**)	Environmental Factors (**T, E, M, P, L**)	Domain Type (**C, M, A, MO**)	Importance (**H, M, L**)	Difficulty (**H, M, L**)
Objective 1: Given the consent form and pretest, the engineering students will mark answers which will identify which of the two groups they belong: experts and novices.						
1.1 Send the brochure to students.	P	Y	M	M	H	L
1.2 Provide students with the consent form.	P	N	M	M	H	L
1.3 Give students the pretest.	D	Y	M	C	H	M
Objective 2: Presented with the sequential graphic video, the engineering students will complete a survey and a cognitive test which will Determine the effectiveness of sequential graphics on learner motivation and achievement.						
2.1 Present the sequential graphics video to students.	P	N	M	M	H	L
2.2 Provide students with CIS survey 1.	S	N	M	M	H	M
2.3 Give students cognitive test 1.	D	N	M	C	H	H
Objective 3: Presented with the simultaneous graphic video, the engineering students will complete a survey and a cognitive test which will Determine the effectiveness of simultaneous graphics on learner motivation and achievement.						
3.1 Present the simultaneous graphics video to students.	P	N	M	M	H	L
3.2 Provide students with CIS survey 2.	S	N	M	M	H	M
3.3 Give students cognitive test 2.	D	N	M	C	H	H

Explanation of Terms (Legend):

Column 2: Knowledge Type (**D, P, S**)

Instructions: Mark the column with D, P, or S (choose only one knowledge type)

According to Jonassen (1999), there are three types of knowledge for an Instructional Designer to consider: (1) Declarative (**D**), (2) Procedural (**P**), and (3) Structural (**S**).

Declarative Knowledge is defined as factual knowledge (e, g., the capital of Florida is Tallahassee), and may be thought of in at least two ways: episodic (knowledge is organized by where, when, who) and semantic knowledge (knowledge of the meaning of words, facts, geography, and things that are classified). Declarative knowledge may also include information about concepts.

Procedural Knowledge is defined as a listing of "how" something is done (e.g., driving a car or preparing a recipe). This knowledge type details activities required to perform a specific task. Procedural Knowledge transforms detail tasks into a habitual process (e.g., fire drill instructions, pre-flight check list).

Structural Knowledge is defined as the linking of one concept to another in order to solve a problem, generate a plan or a strategy by setting conditions for a set of procedures.

Column 3: Prerequisite

Instructions: Mark the column with **Y** (yes) or **N** (no) (choose only one)

If prerequisite knowledge or skills are required in order to complete the task (e.g., A student cannot add 3+2 unless the concept of the number 3 and 2 exist prior to the act of addition), then this should be identified in the worksheet.

Column 4: Environmental Factors (**T, E, M, P, L**)

Instructions: Mark the column with **T** (**T**ime), **E** (**E**nvironment), **M** (**M**edia), **P** (**P**hysical condition), or **L** (**L**earning environment) (multiple factors may apply; choose accordingly)

Time is the estimated time to complete the task. (You will use this estimate to compare actual student time to complete the task. The difference between these two quantities (e.g., estimated time 23 min, actual time 36 min, difference 13 minutes) may result in instructional changes to improve performance.

Environment: Examine the literature to see what environmental concerns are related to the specific task requirements. You may also need to consult with one, or more, instructional experts to gain insight.

Media: What is the best media that will assist in the targeted learners in completing the task? You may need to consider your response to the Environment issue (see above) since this may impose conditions on the media that is best given any environmental constraints.

Physical Condition: These are not the same as Environmental issues (see Watson, 1997: *Task Analysis: An Occupational Performance Approach*. Bethesda, MD: The American Occupational Therapy Association). You may wish to examine Card, Moran, and Newell (1983) in relation to GOMS (Goals, Operators, Methods, Selection) in job task analysis for business, industry, and government.

Learning environment: Considerations should include connectivity, type of hardware/software and peripherals, user interface designs for computer assisted Instruction and distance learning interfaces.

Column 5: Domain (**C, M, A, MO**)

Instructions: Mark the column with **C** (**C**ognitive), **M** (**M**otor), **A** (**A**ffective), or **MO** (**Mo**tivation) (choose only one)

The terms Cognitive, Motor, and Affective are related to Gagne's taxonomy of learning outcomes and are somewhat similar to Bloom's taxonomies of cognitive, affective, and psychomotor outcomes.

Motivation refers to Maslow's Hierarchy of Needs:

Self-Actualization (reaching one's maximum potential)
Esteem (respect from others, self-respect, recognition)
Belonging (affiliation, acceptance, being part of something)
Safety (physical safety, psychological security)
Physiological (hunger, thirst, rest)

<u>Column 6: Importance (**H, M, L**)</u>

Instructions: Mark the column with **H** (**H**igh), **M** (**M**edium), or **L** (**L**ow) (choose only one)

As an instructional designer you will want to determine if a specific task (or subtask) is highly important, of medium importance, or would actually be considered as being at a low level of importance.

<u>Column 7: Difficulty (**H, M, L**)</u>

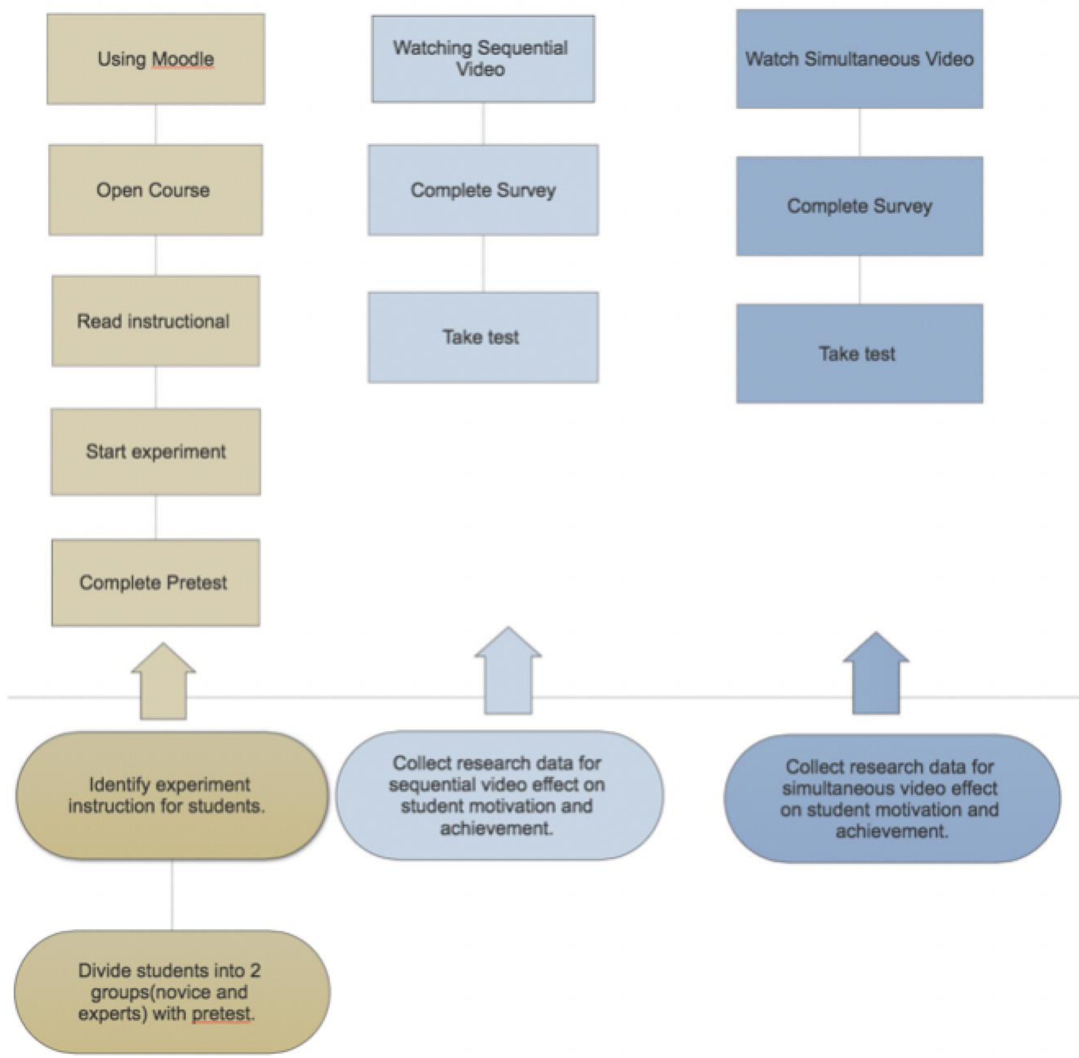
Instructions: Mark the column with **H** (**H**igh), **M** (**M**edium), or **L** (**L**ow) (choose only one)

Similar to Importance, the instructional designer will want to determine the "weight" of the level of difficulty for the specific task. This my impact the amount of time, or placement, or degree of support needed within the instructional project in order to accomplish this task.

Appendix O

ADDIE Design Phase Task D02

Flowchart


Using Moodle
Open Course
Read instructional
Start experiment
Complete Pretest
Watching Sequential Video
Complete Survey
Take test
Watch Simultaneous Video
Complete Survey
Take test
Identify experiment instruction for students.
Collect research data for sequential video effect on student motivation and achievement.
Collect research data for simultaneous video effect on student motivation and achievement.
Divide students into 2 groups(novice and experts) with pretest.

Appendix P

ADDIE Design Phase Task D04

Storyboard (Strategy Description)

Topic: Graphics Visualizations and their Relation to Expertise Level and the Expertise Reversal Effect on Engineering Students	Learning Objective: 1. Given the consent form and pretest, the engineering students will mark answers which will identify which of the two groups they belong: experts and novices. 2. Presented with the sequential graphic video, the engineering students will complete a survey and a cognitive test which will determine the effectiveness of sequential graphics on learner motivation and achievement. 3. Presented with the simultaneous graphic video, the engineering students will complete a survey and a cognitive test which will determine the effectiveness of simultaneous graphics on learner motivation and achievement.
Audience: Engineering students	Total time required to finish: Three weeks

Strategies For the **Course**:

Strategies	The researcher will use the Moodle tools to present the course content.
Orientation to learning	
1. Provide an Overview for entire course	The introduction of the class will include: 1) The name for the course appears on the main Moodle page. 2) There is a resource file containing a contact email address so learners can reach the instructor. 3) Subjects will be provided with a consent form and a brochure explaining the study, how they will participate, and their rights. The documents both include the course introduction,

	instructions for participating, and the amount of time required to complete the course objective.
2.State goal and main objective	The goal of this study is to determine the effectiveness of the two types of graphics on learner achievement and motivation. It will also help instructional designers to choose the best way to present information to students. Additionally, it will show the effectiveness of different learner experience on how they perceive the graphic types.
3. Explain relevance of WBI	The brochure will provide an explanation to the students of how to participate in the experiment.
4.Assist learner recall of prior knowledge, skills, and experience.	Assistance for participants will take place through email when necessary.
5. Provide directions on how to proceed through WBI	1) The brochure and the main Moodle page will includes: • a welcome statement • an explanation of the Framework page 2) Each week the instructor will post a link to Google Drive that will take participants to the links for the videos, surveys, and tests. Each week, the video and the survey will be available first, then a few days later the test will be added.
Motivational strategies	

1. Establishing inclusion	Graphics can get the students interested based on the design elements such as the colors used, length of time, and the voice used for narration. The most important element is the extra information because one of the goals of this experiment is to determine if extra information causes ERE and affects student interest and motivation.
2. Establishing relevance	This experiment has two groups, novice and expert students. The results will show how the novice students who have minimal prior knowledge respond to the videos, and at the same time will show how the expert students with more knowledge respond to them relating to their prior knowledge and experience. Therefore, the content of the videos will be relevant on different levels to all the students.
3. Instilling confidence	Using a good graphics design will increase the students' understanding which will positively affect their confidence and motivate them.

Module information	Describe the content of the screen	Describe in detail the strategies that will use and how they are put into application
Module 1 of 3: **Learning objective of the module:** Student will be able to participate in the experiment. Student will be divided into two groups. Before the pretest, students will agree to participate in the study by signing the consent form. **Classification based on Bloom's taxonomy:** understand **Type of learning (Merrill's content types):** Concepts	1) Give learners an online consent form. 2) Give learners an online pretest.	**Introduction on the content and objective** The framework provides learners a plan for the following week. It includes: a welcome statement for Week 1 Module 1instrictions. directing learners to participate in the online pretest. **Learning cues** Instructor will draw attention to important information about the experiment instructions. **Assessment** The assessment will be accomplished through data collection and analysis as well as dividing students into two groups. **Feedback** Instructor will thank everyone who participates in the experiment by watching the videos and completing the surveys and tests. **Remediation** The tests in the experiment will not affect students' grades, so there is no need for remediation. **Interactivity** The instructor answer any questions the students have through email in a short amount of time.

Module 2 of 3: **Learning objective of the module:** Student will be able to access the sequential video on Google Drive through Moodle . Student will be able to complete the survey on Moodle. Student will be able to take the test on Moodle. **Classification based on Bloom's taxonomy**: Applying **Type of learning (Merrill's content types):** Procedure	1) Give learners the sequential graphics video. 2) Give learners the survey. 3) Give learners the class test.	The instructor provides learners with a plan for the week. It includes: • Module 2 objectives • an instructor request to participate in the study by viewing the video, completing the survey, and taking the test • a statement that test scores will not affect students' grades **Present the content** A) The first video will be a sequential video with a vector addition topic. B) The survey will give students the opportunity to provide feedback on the sequential video and will show how the video affects student motivation. C) The first test will show how the sequential video affects student achievement. **Learning cues** Instructor will draw attention to important information in the video. **Assessment** A) The researcher will assess the learners' motivation by their survey answers. B) The researcher will assess the leaners achievement by their test scores.

		Remediation The tests in the experiment will not affect students' grades, so there is no need for remediation. **Interactivity** The instructor answer any questions the students have through email in a short amount of time. Describe in detail the WBI strategies you will use and how they are put into application
Module information	Describe the content of the screen	Describe in detail the strategies that will use and how they are put into application
Module 3 of 3: **Learning objective of the module** Student will be able to access the simultaneous video on Google Drive through Moodle. Student will be able to complete the survey on Moodle. Student will be able to take the test on Moodle. **Classification based on Bloom's taxonomy**: Applying **Type of learning (Merrill's content types):** Procedure	1) Give learners the simultaneous graphics video. 2) Give learners the survey. 3) Give learners the class test.	**Introduction on the content and objective** The instructor provides learners with a plan for the week. It includes: Module 3 objectives an instructor request to participate in the study by viewing the video, completing the survey, and taking the test a statement that test scores will not affect students' grades **Present the content:** The first video will be a simultaneous video with a friction topic. The survey will give students the opportunity to provide feedback on the simultaneous video and will show how the video affects student motivation. The first test will show how the simultaneous video affects student achievement.

		Learning cues Instructor will draw attention to important information in the video. **Assessment** The researcher will assess the learners' motivation by their survey answers. **Remediation** The tests in the experiment will not affect students' grades, so there is no need for remediation. **Interactivity** The instructor answer any questions the students have through email in a short amount of time.